Eng. Lib.

SCIENTIFIC AMERICAN
SUPPLEMENT, No. 1873

GENERAL LIBRARY
UNIV. OF MICH
NOV 24 1911

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Copyright, 1911, by Munn & Co., Inc.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXII., No. 1873. NEW YORK, NOVEMBER 25, 1911. Scientific American Supplement $5 a year.
Scientific American and Supplement, $7 a year

Flour Testing

Scientific Methods Employed in the Laboratories of the Paris Bakers' Syndicate

SCIENTIFIC methods have invaded every department of commerce and industry, with the greatest benefit to all concerned. As regards more particularly the production and regulation of the food supply for the population of our civilized countries, there is hardly a step in the complex chain of operations involved, in which modern science and its technical application does not enter. The needs of the soil are gaged by chemical analysis, and artificial fertilizer, a product of a chemical industry, is applied in accordance with the indications thus obtained. The tilling of the soil, the harvesting of the crop, and the thousand and one operations incidental to farming, are being performed by mechanical aids. The crop itself, and the live stock, is modified to suit our needs by methods based on the experimental study of the laws of inheritance and evolution. The storing of reserve stock, rendered necessary by the periodic changes in production which accompany the seasons of the year, as well as by other circumstances, has been developed to a previously unheard of extent by the application (perhaps not always as scientific as it should be) of artificial refrigeration. And last but not least, the protection of the public against the spread of diseased, deteriorated or otherwise injurious food-material is placed in the hands of scientific experts. The excellent work which has been done in this direction by Dr. Wiley and his department is known to all. But it is not the government only that is interested in the proper control of the purity and quality of foodstuffs. To the producers themselves, especially those engaged in the elaboration of primary into secondary products, it is a vital matter that the material used by them shall satisfy not only the proper sanitary conditions, but shall be free from such defects as would cause trouble in the course of the manufacture of the secondary product, or would impair its quality. Among the materials thus requiring special testing, and of the most importance is the flour used for baking bread.

The bakeries of Paris have formed a well-organized syndicate, which occupies a building in the center of the town. This building contains a number of laboratories and experimental ovens for testing samples of flour which any of the members may send to the establishment. We illustrate a very practical feature which has already given great satisfaction. It was designed by M. Arpain, the technical head of the establishment, who is also Professor at the Agronomic Institute. The bread-making laboratory is so installed that the proper tests can be made upon 12 samples of flour at the same time, and in exactly the same way, in order to establish a fair comparison between them. The same weight of all the samples is taken, and to this is added an equal weight of yeast, water and salt.

After making up the dough for each specimen of flour, it is put into a set of twelve mechanical kneaders such as we represent here, and these are all driven at the same time so that the conditions of kneading are exactly the same for all the samples. The dough is then taken from the kneaders and is made up into loaves, and these are then baked in the ovens belonging to the laboratory. After baking, the loaves are weighed, examined and classified in the order of whiteness, etc. Such tests are made once a month at certain specified dates so that samples can be submitted beforehand. The tests cover all the data which are needed as to judge of the quality of the flour, and include chemical tests performed by the corps of chemists in other laboratories of the establishment. Among the points determined is, for example, the amount of moisture in the flour and the percentage of nutritive matter in the shape of gluten. The tests made by the baking process bring out other points such as the weight of bread per 100 pounds of flour and the rank which the bread occupies in the scale of whiteness.

The chemical and microscopic analyses which are made in the laboratory are divided into two classes, commercial and complete. The commercial or rough analysis gives a fair estimate of the market value of the flour. It comprises the determination of the percentage of moisture, gluten, hydration water of the gluten; also a microscopic examination and the observation of the general aspect, odor and taste. The complete analysis of the flour goes further, and takes account of fatty matter, ash, acidity; it also includes the search for adulterations. As for these a very good indication is given by micro-photography, and the laboratory is well fitted up in this respect.

Mechanical Kneaders at the Flour-testing Station of the Bakers' Syndicate, Paris.

Radio-Telegraphy—I.*

The Pioneer of the Art Gives An Account of Its Development

By Commendatore G. Marconi

THE practical application of electric waves to the purposes of wireless telegraphic transmission over long distances has continued to extend to a remarkable degree during the last few years, and many of the difficulties which at the outset appeared almost insurmountable have been gradually overcome—chiefly through the improved knowledge which we have obtained in regard to the subject generally and to the principles involved.

The experiments which I have been fortunate enough to be able to carry out on a much larger scale than

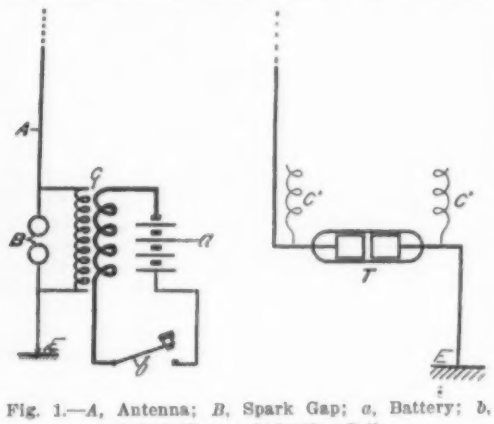


Fig. 1.—*A*, Antenna; *B*, Spark Gap; *a*, Battery; *b*, Switch Key; *c*, Induction Coil.
Fig. 2.—*T*, Detector; *E*, Earth; *C'C'*, Circuit Containing the Detector (Coherer).

THE ORIGINAL MARCONI SYSTEM (1896).

can be done in ordinary laboratories have made possible the investigation of phenomena often novel and certainly unexpected.

Although we have—or believe we have—all the data necessary for the satisfactory production and reception of electric waves, we are yet far from possessing any very exact knowledge concerning the conditions governing the transmission of these waves through space, especially over what may be termed long distances. Although it is now perfectly easy to design, construct, and operate stations capable of satisfactory commercial working over distances up to 2,500 miles, no really clear explanation has yet been given of many absolutely authenticated facts concerning these waves. Some of these hitherto apparent anomalies I shall mention briefly in passing.

Why is it that when using short waves the distances covered at night are usually enormously greater than those traversed in the daytime, while when using much longer waves the range of transmission by day and night is about equal, and sometimes even greater by day?

What explanation has been given of the fact that the night distances obtainable in a north-southerly direction are so much greater than those which can be effected in an east-westerly one?

Why is it that mountains and land generally should greatly obstruct the propagation of short waves when

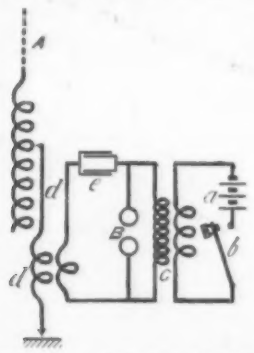


Fig. 3.—*A* Antenna; *d*, Inductive Coupling of Antenna With Condenser Circuit; *e*, Condenser; *B*, Spark Gap; *c*, Induction Coil; *a*, Battery; *b*, Switch Key.

sun-light is present, and not during the hours of darkness?

The general principles on which practical radio-telegraphy is based are now so well known that I need only refer to them in the briefest possible manner.

Wireless telegraphy, which was made possible by the fields of research thrown open by the work of Faraday, Maxwell, and Hertz, is operated by electric waves which are created by alternating currents of very high frequency induced in suitably placed elevated wires or capacity areas. These waves are received or picked up at a distant station on other elevated conductors tuned to the period of the waves, and the later are revealed to our senses by means by appropriate detectors.

My original system as used in 1896 consisted of the arrangement shown diagrammatically in Fig. 1, where an elevated or vertical wire was employed. This wire sometimes terminated in a capacity, or was connected to earth through a spark gap.

By using an induction coil or other source of sufficiently high-tension electricity, sparks were made to jump across the gap; this gave rise to oscillations of high frequency in the elevated conductor and earth, with the result that energy in the form of electric waves was radiated through space.

At the receiving station (Fig. 2) these waves induced oscillatory currents in a conductor containing a detector, in the form of a coherer, which was usually placed between the elevated conductor and earth.

Although this arrangement was extraordinarily efficient in regard to the radiation of electrical energy, it had numerous drawbacks.

The electrical capacity of the system was very small, with the result that the small amount of energy in the aerial was thrown into space in an exceedingly short period of time. In other words the energy, instead of giving rise to a train of waves, was all dissipated after only a few oscillations, and, consequently, anything approaching good tuning between the transmitter and receiver was found to be unobtainable in practice.

Many mechanical analogies could be quoted which show that in order to obtain syntony the operating energy must be supplied in the form of a sufficient number of small oscillations or impulses properly timed. Acoustics furnish us with numerous examples of this fact, such as the resonance produced by the well-known tuning-fork experiment.

Other illustrations of this principle may be given, e. g., if we have to set a heavy pendulum in motion by means of small thrusts or impulses, the latter must be timed to the period of the pendulum, as otherwise its oscillations would not acquire any appreciable amplitude.

In 1900 I first adopted the arrangement which is now in general use, and which consists (as shown in Fig. 3) of the inductive association of the elevated radiating wire with a condenser circuit, which may be used to store up a considerable amount of electrical energy and impart it at a slow rate to the radiating wire.

As is now well known, the oscillations in a condenser circuit can be made to persist for what is, electrically, a long period of time, and it can be arranged, moreover, that by means of suitable aerials or antennæ these oscillations are radiated into space in the form of a series of waves, which through their cumulative effect are eminently suitable for enabling good tuning or syntony to be obtained between the transmitter and receiver.

The circuits, consisting of the condenser circuit and the elevated aerial or radiating circuit, were more or less closely coupled to each other. By adjusting the inductance in the elevated conductor, and by the employment of the right value of capacity or inductance required in the condenser circuit, the two circuits were brought into electrical resonance, a condition which I first pointed out as being essential in order to obtain efficient radiation and good tuning.

The receiver (as shown in Fig. 4) also consists of an elevated conductor or aerial connected to earth or capacity through an oscillating transformer. The latter also contains the condenser and detector, the circuits being made to have approximately the same electrical time period as that of the transmitter circuits.

At the long-distance station situated at Clifden in Ireland, the arrangement which has given the best results is based substantially upon my syntonic system of 1900, to which have been added numerous improvements.

An important innovation from a practical point of view was the adoption at Clifden and Glace Bay of air condensers composed of insulated metallic plates suspended in air at ordinary pressure. In this manner we greatly reduce the loss of energy which would take place in consequence of dielectric hysteresis were a glass or solid dielectric employed. A very considerable economy in working also results from the absence of dielectric breakages, for, should the potential be so raised as even to produce a discharge from plate to plate across the condenser, this does not permanently affect the value of the dielectric, as air is self-healing, and one of the few commodities which can be replaced at a minimum of cost.

Various arrangements have been tried and tested

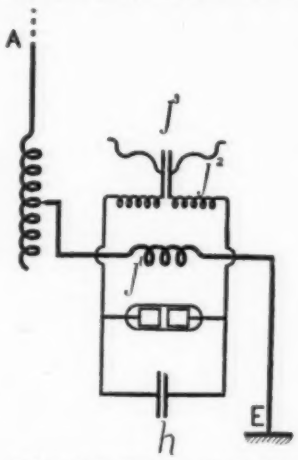


Fig. 4.—*A*, Antenna; *h*, Condenser; *f f² f²*, Oscillating Transformer Coupling; *E*, Earth.

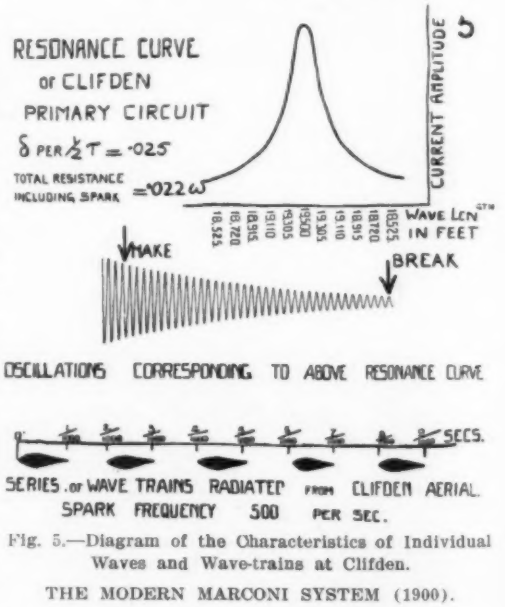


Fig. 5.—Diagram of the Characteristics of Individual Waves and Wave-trains at Clifden.

THE MODERN MARCONI SYSTEM (1900).

for obtaining continuous or very prolonged trains of waves, but it has been my experience that, when utilizing the best receivers at present available, it is neither economical nor efficient to attempt to make the waves too continuous. Much better results are obtained when groups of waves (Fig. 5) are emitted at regular intervals in such a manner that their cumulative effect produces a clear musical note in the receiver, which is tuned not only to the periodicity of the electric waves transmitted, but also to their group frequency.

In this manner the receiver may be doubly tuned, with the result that a far greater selectivity can be obtained than by the employment of wave-tuning alone.

In fact, it is quite easy to pick up simultaneously different messages transmitted on the same wave-length, but syntonized to different group frequencies.

So far as wave tuning goes, very good results—almost as good as are obtainable by means of continuous oscillations—can be achieved with groups of waves, the decrement of which is in each group 0.03 or 0.04, which means that about thirty or forty useful oscillations are radiated before their amplitude has become too small to affect perceptibly the receiver.

The condenser circuit at Clifden has a decrement of from 0.015 to 0.03 for fairly long waves.

This persistency of the oscillations has been obtained by the employment of the system shown in Fig. 6, which I first described in a patent taken out in September, 1907. This method eliminates almost

* Discourse delivered at the Royal Institution and published in *Nature*.

completely the spark gap and its consequent resistance, which, as is well known, is the principal cause of the damping or decay of the waves in the usual transmitting circuit.

The apparatus shown in Fig. 6 consists of a metal disk *a* having copper studs firmly fixed at regular intervals in its periphery and placed transversely to its plane. This disk is caused to rotate very rapidly between two other disks *b* by means of a rapidly revolving electric motor or steam turbine. These side disks are also made slowly to turn round in a plane at right angles to that of the middle disk. The connections are as illustrated in the figure. The studs are of such length as just to touch the side disks in passing, and thereby bridge the gap between the latter.

With the frequency employed at Clifden, namely, 45,000, when a potential of 15,000 volts is used on the condenser, the spark gap is practically closed during the time in which one complete oscillation only is taking place, when the peripherical speed of the disk is about 600 feet a second. The result is that the primary circuit can continue oscillating without material loss by resistance in the spark gap. Of course, the number of oscillations which can take place is governed by the breadth or thickness of the side disks, the primary circuit being abruptly opened as soon as the studs attached to the middle disk leave the side disks.

The sudden opening of the primary circuit tends to quench immediately any oscillations which may still persist in the condenser circuit; and this fact carries with it a further and not inconsiderable advantage, for, if the coupling of the condenser circuit to the aerial is of suitable value, the energy of the primary will have practically all passed to the aerial circuit during the period of time in which the primary condenser circuit is closed by the stud filling the gap between the disks prevents the energy returning to the condenser circuit from the aerial as would happen were the ordinary spark gap employed. In this manner the usual reaction which would take place between the aerial and the condenser circuit can be obviated, with the result that with this type of discharger and with a suitable degree of coupling the energy is radiated from the aerial in the form of a pure wave,

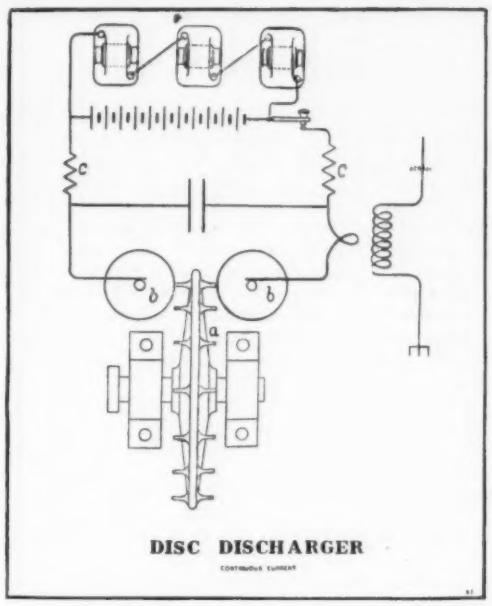


Fig. 6.—The Rotary Disc Discharger Used at Clifden.

the loss from the spark-gap resistance being reduced to a minimum.

I am able to show a resonance curve taken at Clifden, which was obtained from the oscillations in the primary alone (Fig. 5).

An interesting feature of the Clifden plant, especially from a practical and engineering point of view, is the regular employment of high-tension direct current for charging the condenser. Continuous current at a potential which is capable of being raised to 20,000 volts is obtained by means of special direct-current generators; these machines charge a storage battery consisting of 6,000 cells all connected in series, and it may be pointed out that this battery is the largest of its kind in existence. The capacity of each cell is 40 ampere hours. When employing the cells alone, the working voltage is from 11,000 to 12,000 volts, and when both the direct-current generators and the battery are used together the potential may be raised to 15,000 volts through utilizing the gassing voltage of the storage cells.

For a considerable portion of the day the storage battery alone is employed, with a result that for sixteen hours out of the twenty-four no running machinery need be used for operating the station with the single exception of the small motor revolving the disk.

The potential to which the condenser is charged reaches 18,000 volts when that of the battery or generators is 12,000. This potential is obtained in consequence of the rise of potential at the condenser plates, brought about by the rush of current through the choking or inductance coils at each charge. These coils are placed between the battery or generator and the condenser *c*, Fig. 6.

No practical difficulty has been encountered either at Clifden or Glace Bay in regard to the insulation and maintenance of these high-tension storage batteries. Satisfactory insulation has been obtained by dividing the battery into small sets of cells placed on separate stands. These stands are suspended on insulators attached to girders fixed in the ceiling of the battery-room. A system of switches, which can all be operated electrically and simultaneously, divides the battery into sections, the potential of each section being low enough to enable the cells to be handled without inconvenience or risk.

(To be continued.)

A Unique Temperature Curve Tracer

Its Use for Registering Recalescence Curves

THE accompanying illustration, Fig. 1, and drawings, Figs. 2 and 3, show the construction, method of operation and curves made by a novel English instrument designed by Mr. H. Brearley of Sheffield for obtaining recalescence curves on a very open scale and with rectangular co-ordinates. It may perhaps be well to recall very briefly the nature of the phenomenon of

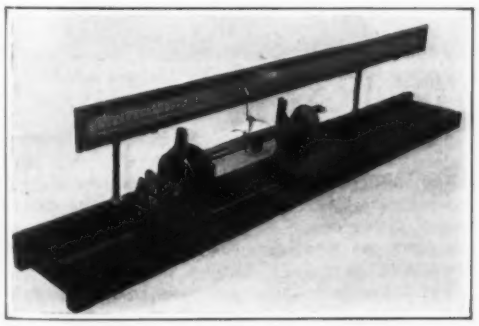


Fig. 1.—Perspective View of the Brearley Temperature Curve Tracer.

recalescence. When steel is heated at a constant rate of heat supply, it is found that on reaching a temperature of about 740 deg. C. there is a sudden break in the rate of temperature. On subsequent cooling there is a similar break at about 707 deg. C. The steel, after reaching this point, is suddenly found to rise again to 710 deg. C. This phenomenon is termed recalescence, and the point at which it occurs, the recalescence point.

This apparatus is not limited to the obtaining of recalescence curves but may also be used for tracing any curve in which the deflections of a galvanometer are co-ordinated with time. It is semi-automatic in action so that the curves are obtained with a minimum of trouble. The diagram Fig. 2 shows the tracer mounted on a platform *B*, which supports a scale 1½ meters long. The instrument is worked in conjunction with a thermo-couple *T* and reflecting galvanometer *M* and for this work an Ayrton Mather galvanometer is used, except that the suspension strip is stronger than usual in order to give a more steady zero reading.

It may be stated that the principle made use of consists in fixing a rotating drum *D* underneath the galvanometer scale *A* and providing means to keep a pointer coincident with the moving spot of light. A pen *P* is attached to the under side of this pointer and is in continuous contact with the chart of the rotating drum. The curve traced out on the chart therefore co-ordinates the galvanometer deflections with time. From drawing Fig. 2 it will be seen that the light from a Nernst lamp is thrown on the galvanometer, and is reflected back on to the scale *A*. The sensitivity is so adjusted by means of a resistance *R*, in series with the thermo-couple *T*, that a full scale deflection across the 1½-meter scale *A* corresponds to a range of say 0.1500 deg. C., when the platform is fixed at a distance of about 2 meters from the galvanometer. The tracer apparatus proper has a clock-work, which rotates a drum *D*, through gear wheels, a revolution of the drum being made once every 10 minutes or 30 minutes as desired. *N* is a sliding carriage which can be moved in a direction parallel to the scale by means of a long screw *S*, turned by the hand wheel *H*. This sliding carriage *N* carries a pointer *K* and a pen *P*, which rests continuously on a chart wound around the drum *D*. As the drum has a circumference of 360 millimeters and a width of 300 millimeters the records of temperature are obtained on a very open scale.

The curve tracer itself is independent of the long scale *A* and can be moved up or down the platform so that the range of the drum can be made to correspond

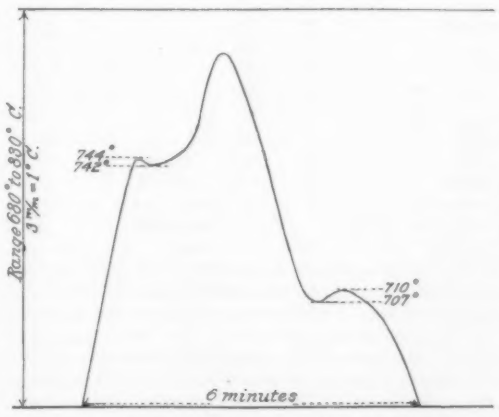


Fig. 3.—Time-temperature Curve of a Sample of Steel. Note the Recalescence at 707 Deg. Cent. on the cooling Portion.

with any 300 millimeters of the scale. A preliminary heating of the steel specimen is made to ascertain the approximate position of the recalescence point on the long scale *A* and the tracer is moved to a position so that this recalescence point shall be well within the range of the drum *D*. The proper test is then carried

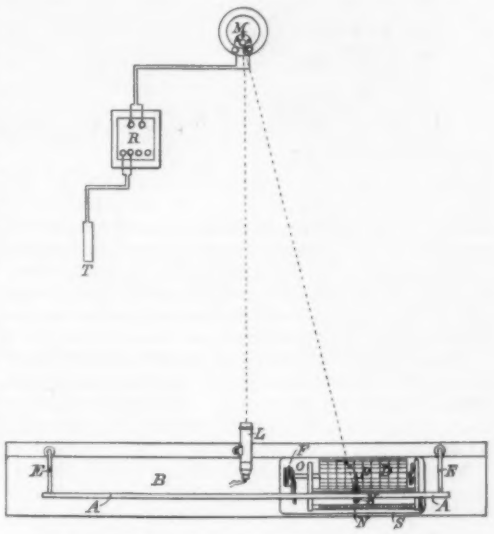


Fig. 2.—Plan of the Brearley Tracer.

out by again gradually heating the steel specimen and noting the corresponding deflections of the spot of light on the scale *A*. As soon as this spot of light comes within the range of the tracer drum, a handle is turned so as to keep the pointer *K* coincident with the spot of light. At the same time the drum *D* is made to rotate, and as the spot of light moves along this portion of the range the pen *P* marks on the chart a time curve of the temperature. The diagram Fig. 3 is a reproduction on a reduced scale of an actual curve taken by means of one of these tracers.

Drying Picture Post Cards.—Amateur photographers sometimes have difficulty in drying picture post cards. The cardboard, on account of its thickness, retains the moisture for a long time. A handy method of assisting the process of drying is to lay the cards upon pieces of corrugated cardboard, such as is used for packing. In order to flatten out the cards after drying, pass a wet sponge or rag over the address side, and lay the post card between two pieces of blotting paper under pressure.—*Cosmos.*

Electricity in Ice Plants*

The Ideal Method of Operation

By Aug. C. Smith

The question of electricity in ice plants is engaging the attention of central stations and power companies to no small extent, and likewise should be of similar interest to the manufacturers of refrigerating and electrical machinery.

Electric motors, operating ammonia compressors for refrigeration, have been in use for some time, but it is only of very recent years that they have been applied to compressors for ice making, especially on a large scale.

There have been many problems to overcome in applying electric power to ice making. One, the question of pure or distilled water, where the argument advanced was that if it is necessary to boil the water, why not produce live steam and operate steam-driven compressors, thereby getting power as a by-product at a cost of but little more? Another, flexibility of speed-control in the electric motor as compared with the steam-driven compressor for meeting varying atmospheric conditions, etc. This problem appeared even more serious when the type of motor using central-station power in most cases would be of the A. C. induction type.

Where pure water was obtainable, the plate system of ice making helped to solve the first of these problems by taking the water as received and applying proper systems of filtration and agitation. To the writer's knowledge, this was the first electrically-equipped commercial ice plant on a large scale where purchased electric power was used and the A. C. induction type of motor applied to this class of work.

At first the two and three speed induction motor was applied to ammonia compressors, so that by the use of switching devices, changing the number of poles of the motor, the speed of the compressor could be varied, but only in two or three fixed steps. To still further extend this variation, different sizes of motor pulleys were at times kept on hand.

This arrangement does not provide the flexibility necessary or even desired, but it was economical from a power-consuming standpoint. On the contrary, however, it imposed a very low power factor in the motor when operating at reduced speed.

Finally the standard type of variable-speed induction-motor was applied, having external resistance-control and giving a flexibility of speed-range for the compressor equal to that of the steam-driven compressor. This was accompanied with poorer efficiency from a power-consuming standpoint when operating at reduced speeds, the power factor, however, remained practically constant at all speeds. Therefore, in ice plants where, during certain seasons of the year, there is a wide difference in output, and variable speed motors are used, better economy can be obtained by having two or more compressor units, proportioned with relation to one another, according to the local operating requirements of the plant. From an economic standpoint this is a very important detail in the engine-room design and should receive careful consideration.

THE PLATE SYSTEM.

In Fig. 1 we have a view of the engine room of an ice plant using the plate system of ice making. The compressor is of 100 ton (ice) capacity when operating at 62 r. p. m., is of the horizontal double-cylinder type, and is driven by rope from a 200 horse-power three-phase, 25-cycle, 2,200-volt induction motor. The motor is small for the full capacity of the compressor, so the latter is operated at 54 r. p. m. at reduced capacity. The motor when originally installed was constant speed, but since then it has been changed to variable speed by the introduction of external-resistance control in the secondary of the motor, giving a range in speed from normal in 13 steps to 50 per cent of normal. It is also possible to disconnect one side of the compressor, operating only the other side as a single engine, thereby increasing further the flexibility of the plant. There is now being installed in this plant another unit of 30-ton (ice) capacity. This machine will be operated by a 100 horse-power three-phase, 25-cycle, 2,200-volt variable speed induction motor. This smaller unit will be used alone in winter months, and in summer in connection with the larger unit when necessary. The water in this plant is taken from the city supply, filtered, and turned into the tanks, producing excellent, pure, clear ice. During the process of freezing, the water is constantly agitated by means of air which is supplied by a small blower operated by a 7½ horse-power motor.

In addition there is the following auxiliary apparatus operated by three-phase, 25-cycle, 440-volt induction motors:

Water pump for condenser belted to 7½ horse-power motor.

Water pump for tanks direct-connected to 6 horse-power motor.

Brine pump belted to 2 horse-power motor.

Ice saw by chain drive to 3 horse-power motor.

Two tilting tables, each belted to 2 horse-power motor.

One ton ice elevator, belted to 3 horse-power motor.

Two cranes, each equipped with a 3 horse-power and 5 horse-power motor.

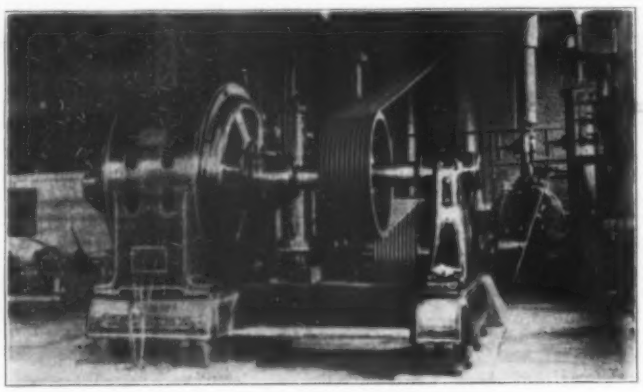


Fig. 1.—Engine Room—Plate System.

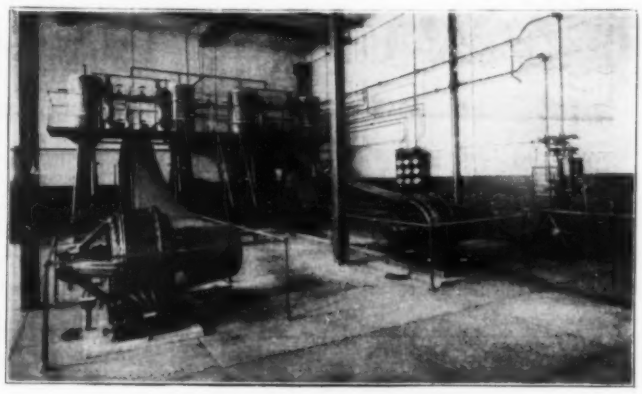


Fig. 2.—Engine Room—Can System.

The following table shows the production and energy-consumption of this plant monthly for the year 1910:

POWER CONSUMPTION MONTHLY FOR A PERIOD OF ONE YEAR IN AN ELECTRICALLY OPERATED 100-TON ICE PLANT USING THE PLATE SYSTEM.

The Crystal Ice and Storage Co., Buffalo, N. Y.

1910.	Tons of Ice—Month.	Tons of Ice—Daily Av.	Tons of Ice—Max. H. P.	H. P. Hours.	Max. H. P. Per Ton.	H. P. H. Per Ton.
Jan.	....	....	...	10,314	....	.....
Feb.	1,420	50.7	145	98,214	2.86	69 2
Mar.	1,400	45.2	153	105,845	3.38	75.6
Apr.	1,168	38.9	139	78,933	3.58	67 6
May	1,786	57.6	138	101,798	2.40	57.0
June	1,037	34.6	278	120,720	8.00	116.4
July	2,294	74.0	280	201,791	3.78	88.0
Aug.	1,800	58.1	290	209,200	4.98	116.2
Sept.	2,244	74.8	283	198,157	3.78	88.3
Oct.	1,115	36.0	149	117,363	4.13	105.3
Nov.	1,019	34.0	141	98,320	4.14	96.5
Dec.	1,356	43.7	139	104,398	3.19	77.0
	16,639			1,445,053		86.8

The foregoing figures show some considerable variation in results from month to month during the year 1910, caused by local conditions pertaining to the operation of this plant during that period. One variation in particular was caused by operating at reduced capacity at intervals during certain months. This illustrates the necessity of a division of compressor unit, as previously mentioned, which this plant is now arranging for, and which will tend to reduce greatly the resultant cost of production.

It will be noted that the total annual production is 16,639 tons of ice, with an energy consumption of 1,445,053 horse-power hours, equivalent to 86.8 horse-power hours per ton of ice average for the year.

The total electric power cost for all energy supplied, including that for auxiliaries and lighting during this annual period, was $5,917.00. The cost per ton of ice was as follows:

Power	35.56 cents
All labor, including tank room and handling	36.00 cents
Total	71.56 cents

September, 1911.

THE CAN-SYSTEM.

The operations in the can-system differ from those of the plate-system. In the can-system the water is first distilled or evaporated, and in so doing it is customary to raise the water to high-pressure steam, using this steam for power purposes in the operation of the plant machinery and condensation therefrom for ice, after separating the engine oils, grease, dirt, etc.

As the condensed steam from the plant machinery is never sufficient to supply all the water needed for ice, a considerable amount of live steam is also used.

It would be considerably more expensive to operate a can-system plant by purchased electric power and evaporate the water by the usual boiler method, than by steam power where the necessary power is obtained as a by-product, and the exhaust steam is used for making ice. To overcome this excessive cost when using purchased power, supplementary distilling apparatus is used in connection with a comparatively small boiler equipment, so that for a given amount of fuel used a considerably greater amount of distillate is obtained than can be produced by usual boiler evaporation.

A 100-ton (ice) can-system plant equipped and operated in this manner is described herewith.

The boiler-room equipment consists of two 85 horse-power horizontal tubular boilers with mechanical stokers, either one of which is more than sufficient to evaporate the necessary water for the full 100 tons of ice in 24 hours.

Fig. 2 illustrates the engine-room equipment of this plant, which consists of two vertical 45-ton (ice) two-cylinder, single-acting ammonia compressors, operating at full normal speed of 72 r. p. m., each belt driven by a 175 horse-power 500 r. p. m. three-phase, 25-cycle, 2,200-volt variable-speed induction motor.

By means of the speed control of these motors the compressors can be operated at thirteen different speeds continuously, from 72 r. p. m. maximum to 11 r. p. m. minimum.

The incoming wires for the supply of electric energy enter a suitable apartment through the walls and lead first to a primary incoming line panel, equipped with disconnecting switches and an automatic oil switch. From this panel the conductors are carried to individual motor-panels, and thence to the motors. The resistance control is connected through a drum controller to the rotor of the induction motor.

The efficiency of this type of motor is low at reduced speed, as the total energy input remains nearly constant for all speeds. It does, however, provide a flexibility of speed control practically equivalent to that of the steam-operated compressor, which is a very essential item in providing for varying atmospheric conditions. When it is necessary to reduce the output of this plant to one-half capacity or less, only one compressor unit is operated, a condition which exists during about four winter months of the year. The efficiency at this point of operation is as good as that obtained when operating the plant at full capacity. There is, however, a point which comes between one-half and full capacity of output when both compressors are operated at slightly

* Paper read before the Western Society of Engineers, and reproduced here by courtesy of the editor of the *Journal*.

reduced speed; this condition exists for two or three months in the year, at which time the efficiency is somewhat lower than that obtained at full capacity.

It is with these varying conditions of operation in view that the engine-room design in each and every plant must be given very careful consideration with regard to its particular operating conditions, so that the proportioning of compressor units with relation to one another will be such that for varying conditions of plant output throughout the year the compressors can be operated singly or together at or near full capacity, and thereby permit the motors to be operated at or near their normal full speed. The engine-room design can be carried to such a degree of refinement that the first cost will overbalance the resultant benefits derived from operating efficiencies. This must be guarded against by a little good judgment and some comparative figuring.

In addition to the foregoing electrical apparatus, the plant is equipped with two 20-kilowatt 2,200-volt primary, 440-volt secondary, transformers for supplying power to auxiliaries, as follows:

Four 3 horse-power constant-speed motors direct-connected to brine agitators.

One 25 horse-power variable-speed motor belted to condenser pump.

One 5 horse-power variable-speed motor belted to pumping-out machine.

One 5 horse-power variable-speed motor belted to soft-water pump.

One 1½ horse-power constant-speed motor belted to water-softener mixer.

Two 3 horse-power variable-speed crane motors.

Making a total of 54½ horse-power in auxiliary motors.

Fig. 3 shows a view of the distilling apparatus which is supplementary to the boiler equipment. This still consists of 12 cells, arranged in two banks, having a total capacity for handling 50,000 gallons of water in 24 hours, and for every pound of steam delivered to it at 100 pound-pressure the still is supposed to produce from 6 to 7 pounds of distillate, or it might be said, at this rate of distillation, for every pound of fuel from 40 to 50 pounds of distilled or evaporated water can be obtained.

A special set of water-softeners is in use in this plant. The function of this apparatus is to soften the water received from the city supply to prevent scaling in the distilling equipment. After the water has been treated in the softener tanks and then filtered, it is pumped to the last or twelfth cell of a distilling equipment in which it is raised to a little above 212 deg. Fahr. Therefore, any scale-forming matters which are not entirely eliminated in the process of treatment and filtration will be deposited in this last cell, and as all of the raw water fed to the other eleven cells is drawn from this last cell they are kept clean and free from scale.

This water-softening equipment has proven very satisfactory and has effected a marked increase in efficiency in the still over the results prior to its installation.

Fig. 4 is a view of the tank room. Its arrangement is the same as that for a steam plant with the exception that cranes are electrically operated and the agitators driven by direct-connected vertical-shaft induction motors.

The ice produced by this plant is beautifully clear, so much so that a photograph has been taken of a man standing behind a couple of cakes of ice placed on edge, one above the other, to get a large enough screen to hide the man.

The following table gives for a period of one year, monthly production, average daily rate of production, maximum horse-power demand, horse-power hours, maximum horse-power per ton, and horse-power hours per ton of ice produced:

POWER CONSUMPTION MONTHLY FOR A PERIOD OF ONE YEAR IN AN ELECTRICALLY OPERATED, 100-TON ICE PLANT USING THE CAN-SYSTEM.

1910.	Tons of Ice—Month.	Tons of Ice—Daily Av.	Max. H. P.	H. P. Hours.	Max. H. P. Per Ton.	H. P. H Per Ton.
Jan.....	1,768	57.0	123	87,070	2.16	49.24
Feb.....	1,549	55.3	137	79,450	2.48	51.29
Mar.....	1,903	61.4	221	93,760	3.60	49.27
Apr.....	2,732	91.1	232	164,558	2.55	60.23
May.....	2,651	85.5	257	165,488	3.01	62.42
June.....	3,024	100.8	300	188,666	2.98	62.39
July.....	3,442	111.0	314	219,265	2.83	63.70
Aug.....	3,503	113.0	300	208,123	2.65	59.41
Sept.....	3,514	117.1	291	209,027	2.49	59.48
Oct.....	3,379	109.0	283	185,177	2.60	54.80
Nov.....	982	32.7	137	88,070	4.19	89.68
Dec.....	1,853	59.8	129	93,914	2.16	50.68
	30,300			1,772,568		58.50

From these figures it will be seen that the total annual production is 30,300 tons of ice, with an energy consumption of 1,772,568 horse-power hours, equivalent to 58.5 horse-power hours per ton of ice, average for the year, with a maximum of 63.7 in July, and a minimum of 49.24 in January (excluding November).

The total electric power cost for all energy supplied, including that for auxiliaries and lighting during this annual period, was $7,079. The coal consumption for evaporation and distillation of all water is 85.47 pounds per ton of ice at $2.50 per ton of 2,000 pounds.

The cost per ton of ice was as follows:

Power	23.36 cents
Fuel	10.68 cents
Engine and boiler room labor	15.51 cents
Total	49.55 cents
Or per 100 tons in 24 hours	$49.55
The cost of tank room labor was	12.55
Making a total cost per 100 tons of ice delivered to the platform	$62.10

For purposes of general comparison the following figures illustrate the cost of producing 100 tons of ice in 24 hours by a steam-operated plant based upon a boiler evaporation of 8 to 1, coal cost of $2.50 per ton delivered, and a daily evaporation of 250,000 pounds of water, with all power derived therefrom as a by-product.

Fuel		$39 06
Engine and boiler room labor:		
1 Chief Engineer	$5.00	
1 Asst. Engineer	3.00	
2 Oilers	5.00	
2 Firemen	6.00	19.00
		$58.06

The foregoing results demonstrate that electric power can be successfully applied to commercial ice plants, especially on a large scale. The question of relative cost of production between a plant operated by purchased electric-power and generated steam-power rests entirely with the rate at which electric power is obtainable.

The plants described herein obtain a rate for electric power of $36 per horse-power per year when the monthly maximum demand is 100 horse-power; $32.50 when 200 horse-power, and $30 when 300 horse-power. The monthly minimum is placed low, so that during the winter months when the energy consumption is light the plant will not be penalized by a heavy fixed charge.

Electric power applied to ice plants offers the same advantages over steam power as in other industrial plants. These advantages have long been recognized, so that the use of electric power in other industries has become almost universal. There is, furthermore, no question as to the quality and purity of product obtained from the electrically-operated ice plant, while with the steam-operated plant, wherein the exhaust is used for ice, there always exists that uncertainty of contamination from engine oils, grease, dirt, etc. It is an admitted fact that after steam has once been associated with oil (the oil at this state being almost a gas) it is difficult to clear the water of all traces of its presence, or should a break occur in the apparatus performing this work, the whole mass of water is liable to show traces of oil for some time to come.

The operating cost of the electric plant should therefore be rightfully compared with that of a steam plant which will give the same guarantee of purity of product.

Again, with the application of electric power to ice making and the elimination of coal, we eliminate all the troubles and annoyances coincident to the use of coal, such as storage space, handling facilities, smoke nuisance, etc., all of which are influencing factors in plant location. This question of possible plant location will be one of the important factors in the future in the establishment of a system in our large cities, consisting of a number of comparatively small plants located each with respect to the territory served, as opposed to large capacity plants with distributing stations.

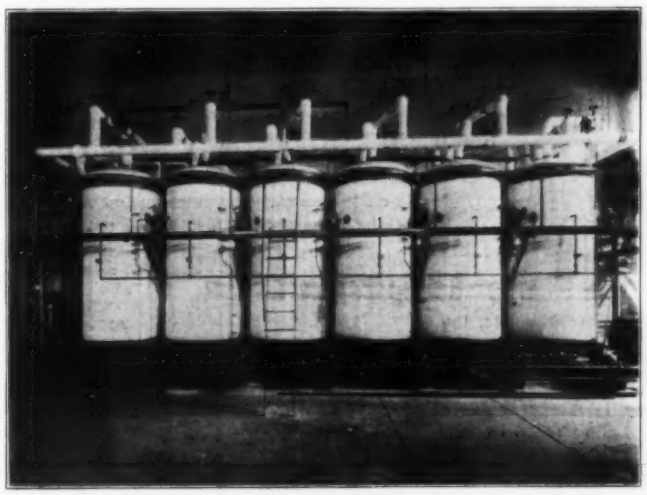
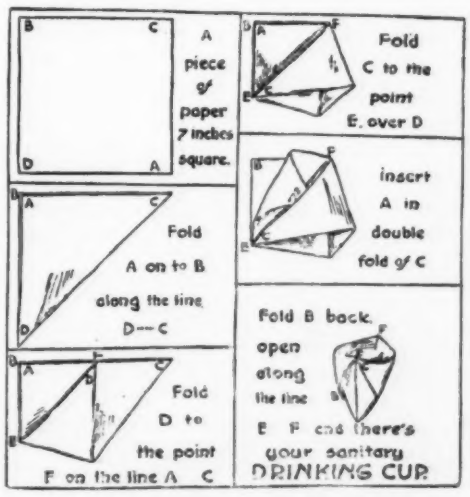


Fig. 3.—Distilling Plant.

Fig. 4.—Tank Room.

Home-Made Sanitary Drinking Cup.

WITH a view of eliminating the dangers of infection from the use of public drinking cups, a set of "plans and specifications" for the manufacture of a sanitary drinking vessel has been prepared. All that is necessary is a piece of paper, seven inches square, which if folded properly, will form a drinking cup that will be sufficiently sanitary for any one. The diagram shows the method of folding the paper so as to make the cup ready for immediate use. There are no sharp edges of paper at the edge of the cup, and hence no danger of cutting the lips. A cup made from an ordinary grade of book paper will keep its shape and hold water for five or ten minutes. If a hard manilla wrapping paper is used the cup will be much more durable. A convenient size cup for general use is made of a piece of paper seven inches square. *Municipal Journal.*


A piece of paper 7 inches square.
Fold C to the point E. over D
Fold A on to B along the line D—C
insert A in double fold of C
Fold D to the point E on the line A C
Fold B back. open along the line E F and there's your sanitary DRINKING CUP

Nickel-First Telephones in Chicago

THERE are over 30,000 of the nickel-first type of telephones now in operation in Chicago, in spite of some opposition which has been presented.—*Electrical Review.*

The Parabola in Aeroplane Surfaces

Some Hints for Drawing Parabolic Curves of Any Desired Type

By G. H. Godley

AEROPLANE constructors are practically agreed that the correct fore-and-aft section for their supporting surfaces is a parabola. The results of practical experience have fully supported the experiments and mathematical proofs of Prof. Montgomery and others, which have been published in various forms. Unfortunately, the parabola is rather a difficult curve to handle, especially in such forms as are employed in aerodynamics; and builders have in many cases sketched out their curves without calculation, only being careful to make the curvature somewhat sharper in the front than in the rear. Although some machines constructed in this slipshod fashion may have flown, there can be no doubt that they would fly better with accurately curved surfaces.

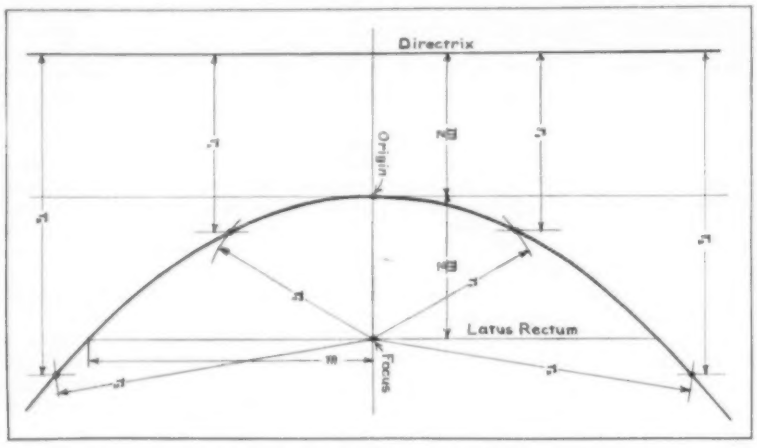


Fig. 1.—How to Draw a Parabola.

The builder generally knows the length of the parabolic arc he wants, and its curvature expressed as the ratio between the "rise" and the length of the chord. If he looks in an engineering handbook for a method of laying out a parabola, he will find many, but all depending on the focal length, which he does not know. To make these methods of value, the relation between curvature, length of chord, and focal length must be established. It may be remarked that as only one half of the whole parabola is used, various approximate methods also fail. This article undertakes to demonstrate mathematically the necessary relations and to give tables based on them which will facilitate the work of the designer.

The parabola is defined as a curve of which every point is equidistant from a fixed point (*focus*) and a fixed line (*directrix*). It will be apparent that the curve passes half-way between the focus and the directrix, and bends back around the former on each side, extending into space indefinitely. All parabolas are of the same shape, just as all circles are; in this respect they differ from the ellipse and the hyperbola. The curvature depends on the part of the parabola from which the arc is chosen.

Customary methods of laying out the parabola depend on the definition as given above. If an arc is described with compasses about the focus as the center, with a radius greater than one-half the distance between focus and directrix, and a line is drawn parallel to the directrix at a distance equal to the radius used, the intersections of line and arc will locate two points on the parabola. Repetition will give enough points to define the curve. In aeroplane work only half the curve is used, the point midway between focus and directrix lying in the front edge of the surface.

Referred to rectangular axes with the origin midway on the perpendicular from focus to directrix, the equation of the parabola is $y^2 = 2mx$, in which m represents the distance between focus and directrix. One of the less generally known properties of the parabola, but a useful one for the purpose, is that, if a chord be drawn between the origin and a point (x_0, y_0) of the parabola, and a line be drawn parallel to that chord and tangent to the parabola at (x_1, y_1), the abscissa x_1 is $1—4x_0$: likewise the tangent cuts the axis of X at the point $(-x_1, 0)$. This may be proved as follows:

The slope of the chord is $\frac{y_0}{x_0} = \frac{\sqrt{2mx_0}}{x_0}$; the slope of any tangent is

$$\frac{dy}{dx}(x = x_1) = \frac{m}{\sqrt{2mx_1}}.$$

$$\text{When } \frac{\sqrt{2mx_0}}{x_0} = \frac{m}{\sqrt{2mx_1}}, \quad x_0 = 4x_1.$$

The equation of the tangent is

$$y - y_1 = \sqrt{\frac{m}{2x_1}}\,(x - x_1);$$

$$\text{when } y = 0, \; -y = \sqrt{\frac{m}{2x_1}}\,(x - x_1);$$

$$\text{but } y = \sqrt{2mx}, \text{ so } x - x_1 = -\sqrt{2mx_1}\,\sqrt{\frac{2x_1}{m}},$$

$$\text{and } x = -x_1, \text{ or } -\frac{1}{4}x_0.$$

With this information it is possible to obtain an algebraic expression for the ratio of curvature, by which aeroplane surfaces are usually described. This ratio is the greatest rise of the curve above the chord, divided by the length of the chord; in common practice it ranges from 1 in 12 to 1 in 20. The rise of the curve is the distance between the tangent and the chord, which is now seen to be $x_1 \cos \alpha$, or $\frac{1}{4}x_0 \cos \alpha$; α being the angle between the chord and the axis of y. Calling the length of chord l, and the ratio of curvature c, $c = \frac{x_0 \cos \alpha}{4l}$. But, by construction, $x_0 = l \sin \alpha$; therefore $c = \frac{1}{4} \sin \alpha \cos \alpha = \frac{1}{8} \sin 2\alpha$, or $\sin 2\alpha = 8c$. Thus the curvature is a function of the angle which strikes off the desired arc of the parabola.

Among the interesting properties depending on this formula, it may be noted that when $c = 1/16$, $\sin 2\alpha = \frac{1}{2}$, $2\alpha = 30°$ and $\alpha = 15°$. There is a definite maximum of curvature; for when $\alpha = 45°$ and $\sin 2\alpha = 1$, $c = \frac{1}{8}$. The curvature of the arc intercepted by the *latus rectum* also works out neatly; when

$$x_0 = \frac{1}{2}m \text{ and } y_0 = m,$$

$$\cos \alpha = \frac{y_0}{\sqrt{x_0^2 + y_0^2}} = \sqrt{\frac{m^2}{\frac{m^2}{4} + m^2}} = \frac{2}{\sqrt{5}}$$

$$\text{and } \sin \alpha = \frac{1}{\sqrt{5}}; \; c = \frac{1}{4}\sin \alpha \cos \alpha$$

$$= \frac{1}{4} \cdot \frac{1}{\sqrt{5}} \cdot \frac{2}{\sqrt{5}} = \frac{1}{10}.$$

Now turn to the relation between curvature and length of arc and the focal length. The length of chord,

$$l = \sqrt{x_0^2 + y_0^2} = \sqrt{x_0^2 + 2mx_0} = \sqrt{l^2 \sin^2 \alpha + 2ml \sin \alpha}$$

$$2m = \frac{l - l\sin^2 \alpha}{\sin \alpha} = \frac{l \cos^2 \alpha}{\sin \alpha}, \text{ and the focal length } \frac{m}{2} = \frac{l \cos^2 \alpha}{4 \sin \alpha}, \text{ or } \frac{cl \cos \alpha}{\sin^2 \alpha}.$$

Of the appended tables the first expresses ratios of curvature in terms of the angle α, and the second gives for each ratio of curvature the value of the functions

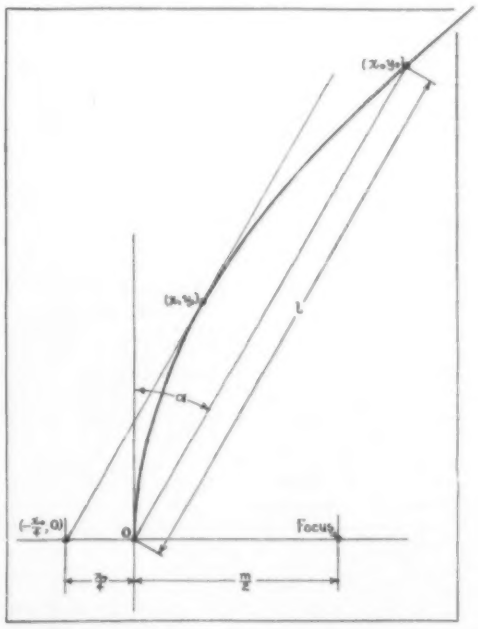


Fig. 2.—Showing Angle of Curvature and Relation Between Tangent and Chord.

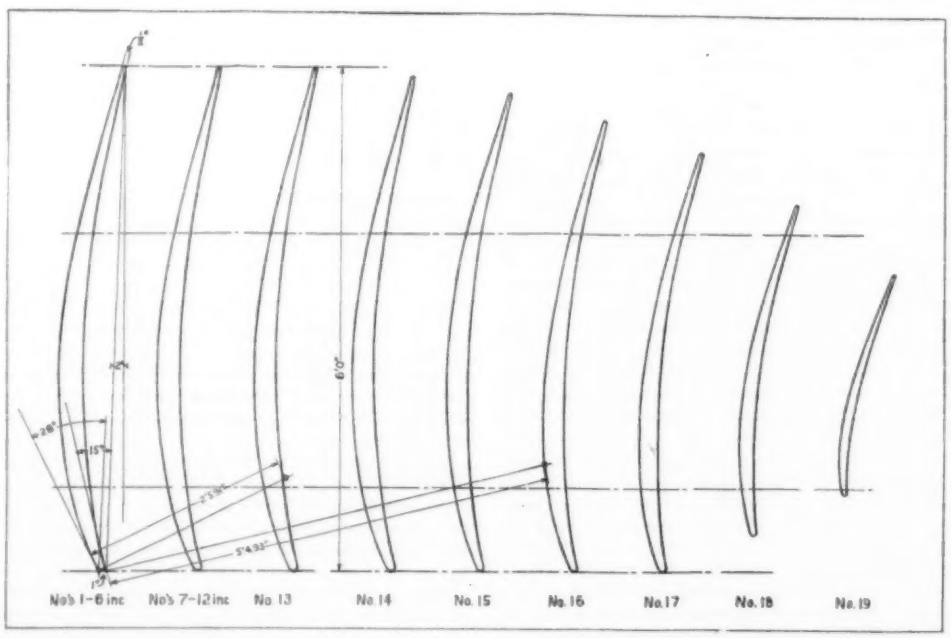


Fig. 3.—Wing Ribs of a Typical Monoplane Showing Curves Laid Out According to Accompanying Table.

RIB CURVATURES OF A TYPICAL MONOPLANE.

Number of Rib.	Projected Length.	Angle of Incidence, θ	Under Surface.			Upper Surface.		
			Actual Length, l.	Angle of Curvature, α	Focal m Length $\frac{}{2}$	Actual Length, l'.	Angle of Curvature, α'	Focal m'. Length, $\frac{}{2}$
1–6 inc.	6′ 0″	2° 0′	6′ 0.04″	15° 0′	5′ 4.93″	6′ 0.04″	28° 0′	2′ 5.91″
7–12 inc.	6′ 0″	2° 0′	6′ 0.04″	15° 0′	5′ 4.93″	6′ 0.04″	27° 0′	2′ 7.50″
13	5′ 11.94″	2° 0′	5′ 11.98″	15° 0′	5′ 4.87″	5′ 11.98″	26° 0′	2′ 9.16″
14	5′ 10.99″	2° 30′	5′ 11.06″	15° 0′	5′ 3.98″	5′ 11.06″	26° 0′	2′ 8.74″
15	5′ 8.87″	3° 0′	5′ 8.97″	14° 30′	5′ 10.77″	5′ 8.97″	25° 0′	2′ 9.51″
16	5′ 5.45″	3° 30′	5′ 5.58″	14° 0′	5′ 3.80″	5′ 5.58″	23° 0′	2′ 11.55″
17	5′ 0.36″	5° 0′	5′ 0.59″	13° 30′	5′ 0.26″	5′ 0.63″	21° 0′	3′ 0.86″
18	4′ 2.85″	7° 0′	4′ 3.18″	13° 0′	4′ 6.06″	4′ 3.29″	18° 30′	2′ 11.52″
19	2′ 9.97″	12° 0′	2′ 10.73″	12° 0′	3′ 3.94″	2′ 10.79″	16° 0′	2′ 5.15″

ANGLES FOR GIVEN CURVATURES.

$\sin 2\alpha = 8c$.

Curvature.	Angle α	Log. Cos α.	Cos α.	Log. Sin α.	Sin α.
1 in 20	11° 47′ 20.7″	9.990741	.978906	9.310289	.204310
1 in 19	12° 27′ 01.9″	9.989665	.976484	9.333642	.215597
1 in 18	13° 13′ 36″	9.988324	.973473	9.359464	.228802
1 in 17	14° 02′ 10.5″	9.986835	.970141	9.384776	.242536
1 in 16	15° 00′ 00″	9.984944	.965926	9.412996	.258819
1 in 15	16° 06′ 55.7″	9.982590	.960705	9.443379	.277574
1 in 14	17° 25′ 29.8″	9.979598	.954110	9.476333	.299456
1 in 13	18° 59′ 23.8″	9.975696	.945575	9.512421	.325403
1 in 12	20° 54′ 18.6″	9.970427	.934172	9.552451	.356822
1 in 11	23° 19′ 44.8″	9.962959	.918246	9.597709	.396013
1 in 10	26° 33′ 54.2″	9.951545	.894427	9.650515	.447214
1 in 9	31° 22′ 01.1″	9.931382	.853851	9.716435	.520517
1 in 8	45° 00′ 00″	9.849485	.707107	9.849485	.707107

VALUES OF m LENGTH AND CURVATURE GIVEN.

$$m = \frac{l \cos^2 \alpha}{2 \sin \alpha}.$$

Curvature.	$\frac{\cos^2 \alpha}{2\sin \alpha}$	l = 4	4½	5	5½	6	6½	7
1 in 20	2.38044	9.5218	10.7120	11.9022	13.0924	14.2864	15.4729	16.6631
1 in 19	2.21135	8.8454	9.9512	11.0568	12.1624	13.2681	14.3738	15.4795
1 in 18	2.07088	8.2835	9.3189	10.3544	11.3898	12.4253	13.4607	14.4961
1 in 17	1.94028	7.7611	8.7312	9.7014	10.6715	11.6517	12.6118	13.5819
1 in 16	1.80244	7.2098	8.1110	9.0122	9.9134	10.8147	11.7159	12.6171
1 in 15	1.66254	6.6501	7.4814	8.3127	9.1439	9.7752	10.6064	11.6378
1 in 14	1.51961	6.0785	6.8383	7.5981	8.3579	9.1177	9.8775	10.6373
1 in 13	1.37385	5.4954	6.1923	6.8693	7.5562	8.2431	8.9301	9.3981
1 in 12	1.22285	4.8914	5.5028	6.1142	6.7257	7.3371	7.9485	8.5599
1 in 11	1.06458	4.2583	4.7906	5.3229	5.8552	6.3875	6.9198	7.4521
1 in 10	.89422	3.5769	4.0240	4.4711	4.9182	5.3653	5.8124	6.2595
1 in 9	.70032	2.8013	3.1515	3.5016	3.8518	4.2019	4.5521	4.9023
1 in 8	.35355	1.4142	1.5910	1.7678	1.9445	2.1213	2.2981	2.4749

of the angle which when multiplied by the length of chord will give the focal length, and also the focal length for a number of convenient chord lengths. Eventually it is probable that the ratio of curvature will largely be discarded, curves being designated simply by the corresponding values of a. The relation may be grasped from the easily remembered cases, the curvature of 1 in 16 gives $a = 15°$, and the curvature of 1 in 8 gives $a = 45°$.

These tables not only allow the designer to find the focal length of the supporting surface curve, but, if the machine's planes are of the double-surface type, they enable him to place a second parabola, for the upper surface, accurately over that of the lower. Suppose the lower surface has a curvature of 1 in 16, and the upper of 1 in 10; then, when the curve for the lower surface has been laid out, simply shift the axes the difference between the corresponding values of a, and, with a focal length suitable for the same chord, lay out the curve for the upper surface.

By way of illustration are given the curves of the surfaces of an aeroplane at present under construction, to be of the monoplane type with a spread of 30 by 6 feet. There are 38 ribs, 19 on each side of the central *fuselage*, spaced 9 inches apart. For convenience they are numbered out from the center in each direction. The lengths of the outer ribs are such as to give the ends of the surfaces a graceful contour similar to that of the Blériot monoplane. The inner 14 ribs on each side have the same angle of curvature; the outer ribs are flatter and more sharply inclined, the extreme outer one on each side having the tangent at its front end horizontal. The reasons for this arrangement do not come within the scope of the present article; the figures are offered simply to show how easily the parabola may be handled, granted a sufficient knowledge of its peculiarities.

Hydraulic Power for Constantinople.—Up to the present the current which is used in the city of Constantinople is supplied from a number of steam plants, but there is a project on foot for building a hydraulic plant at 80 miles from the city on the Sakania River. It is proposed to erect two separate turbine plants on the stream. For the upstream plant the dam will give a 175-foot head of water and yield a mean of 15,000 horse-power, counting on a yearly run of 3,000 hours. The second plant will have about half this output. These two stations will serve for the immediate needs, and a further increase can be made in the future by using a number of small falls in the upper part of the river. As the Anatolia railroad lies near the proposed site, the building work will be easy to carry out.

Operating Costs of Gas-Power Plants

A Valuable Set of Estimates

THE Plant Operations Committee of the Gas Power Section of the American Society of Mechanical Engineers presented at the Pittsburgh meeting of the society a report giving operating costs from four gas-power plants, the names and locations of which were withheld by request of the plant owners. For the purpose of identification the plants were referred to by letters of the alphabet. The essential features of the reports are given as follows by *Power:*

PLANT "A."

Two pressure producers with generators 7 feet in inside diameter, wet scrubbers 7½ feet inside diameter and 18 feet high and dry scrubbers 7 feet square by 3½ feet high. The producers use bituminous coal, costing $2.55 per ton; two tar extractors are operated.

One double-acting single-tandem engine with cylinders 23½x33 inches. The shaft runs in three bearings and is directly coupled to an electric generator. Speed, 150 revolutions per minute.

The plant runs continuously from 6 o'clock Monday morning until midnight Saturday, every week, supplying electricity for light and power.

The report covers two months' operation, during which a total of 308,410 kilowatt-hours of energy were converted; of this, 35,190 kilowatt-hours were used in the plant and 273,220 kilowatt-hours delivered. The cooling water for the engine is used for other purposes after leaving the jackets and it is, therefore, not charged to the operation of the plant.

Operating Costs per Kilowatt-hour Delivered.

	Cent
Fuel	0.2576
Producer-room labor	0.1585
Oil	0.0141
Waste, etc.	0.0024
Engine-room labor	0.0555
Producer repairs	0.0127
Engine repairs	0.0040
Total cost	0.5048

PLANT "B."

One set of Loomis-Pettibone down-draft producers supplying one 500-horse-power engine of the same size and type as in plant "A."

The plant operates 10 hours a day and the figures apply to a period of 15 months. Coal costs $4.53 per ton at the plant.

Operating Costs per Kilowatt-hour.

	Cent
Fuel	0.4460
Water	0.0879
Oil	0.0465
Waste, etc.	0.0335
Producer-room labor	0.1603
Engine-room labor	0.2050
Producer repairs	0.0243
Engine repairs	0.2375
Total cost	1.2410

PLANT "C."

Two sets of Loomis-Pettibone producers, each of 2,000 horse-power rating. Two twin-tandem engines with cylinders 32x42 inches, rated at 1,500 horse-power each. Each engine has two main bearings and drives an electric generator at 107 revolutions per minute. Make-and-break ignition.

Operating Costs per Kilowatt-hour in 1910.

	Cent
Fuel	0.422
Water	0.003
Oil and waste	0.024
Miscellaneous supplies	0.015
Superintendence	0.026
Producer-room labor	0.102
Engine-room labor	0.063
Producer repairs	0.024
Engine repairs	0.004
Electrical repairs	0.005
Total cost	0.688

PLANT "D."

Two 400-horse-power producers with generators 8 feet inside diameter, wet scrubbers 8 feet diameter by 20 feet high and dry scrubbers 6 feet square by 3½ feet high.

Three 250-horse-power vertical engines each having three single-acting cylinders 20x19 inches. Each main shaft has five bearings and is coupled to an electric generator. Speed, 230 revolutions per minute. Make-and-break ignition.

The report covers three months' operation. The total running time was 1,439 hours and the total output 309,300 kilowatt-hours.

The fuel is No. 1 buckwheat anthracite, costing $2.33 per ton.

Operating Costs per Kilowatt-hour.

	Cent
Fuel	0.2828
Oil, waste, etc.	0.0572
Producer-room labor	0.1135
Engine-room labor	0.2640
Producer repairs	0.0249
Engine repairs	0.1496
Total cost	0.8920

Commutator Lubrication

C. MALONE, writing in *Power*, says: The practice of using vaseline or commutator compounds to lubricate commutators, collector rings and brushes, so generally followed, has given me more trouble than the use of a clean cotton cloth saturated in gasoline; holding the cloth lightly against the collector rings or commutator does the work. I do not use grease of any kind. The brushes are all of carbon on the machines that I am running, which are alternators of the revolving-field type, running at 3,600 revolutions per minute, and the usual direct-current exciter."

German Impulse Marine Turbines*

A Review of Recent Developments

AFTER its proved success for land installations the action or impulse type of turbine was by no means so rapidly adapted for marine work as the reaction turbine, but of recent years a very large amount of investigation has been made in many quarters, with the outcome that satisfactory results are now being obtained, and the hope of even greater successes in the future, when large working experience has been gained, is likely to be realized. Several foreign navies have had some scruple in adopting Parsons turbines exclusively, but while there was no alternative for a long time, very strenuous attempts were made to develop turbines other than that produced by the genius of an Englishman. In America therefore the Curtis turbine has been given as much opportunity as possible to prove its worth, while in Germany the A.E.G. turbine has been making much headway. Though in neither case has the success as yet attained been comparable with that of Parsons turbine, it must be remembered that the impulse turbine for marine work is, as compared with the reaction type, of very recent origin, and thus cannot be expected to have reached anything approaching the same degree of perfection. Relative results are always difficult to value accurately, and particularly is this the case with reference to ships and their machinery, so that it is impossible to make any dogmatic assertion as to the superiority of one type of turbine over the other, or as to the predominance of one in the future; but it may be taken as a very significant fact, and indicating the necessity of keeping an open mind, that the British Admiralty has now in commission a cruiser—the "Bristol"—built by John Brown & Company, Ltd., in which impulse turbines of the Brown-Curtis type are installed. These, according to published data on the trials, seem to have given results well up to anticipation.

In 1902 the A.E.G., of Berlin, took up the manufacture of steam turbines for land purposes, and since that time such considerable progress has been made that it is stated that the output in horse-power now exceeds that of the Parsons type. The first marine turbine was made at the Berlin works for the "Kaiser" of the Hamburg-America Line, and this was put into commission in 1905. As regards general construction, no very material alterations have been made since, though as a result of very extensive tests, many great improvements have been effected by certain modifications in the design of more recent marine turbines. As with most impulse turbine installations, a two-shaft arrangement was employed, this being an advantage of the impulse type which is of considerable importance both as regards facility in maneuvering and simplicity of pipe connections. The "Kaiser" had a displacement of 1,925 tons, and the guaranteed speed was 19.5 knots, 20.46 knots actually being obtained on trial. The horse-power was 6,600, and the speed of the turbines at top vessel speed was 565 revolutions per minute. As will be seen from Fig. 2, which gives a sectional elevation of one of the turbines, the reverse stages are in the same cylinder as the ahead. The latter consists of five pressure stages, the first of which has three velocity stages, and the remainder two velocity stages. The low-pressure part of the ahead turbine is formed by an impulse drum which, however, is designed for, and necessarily gives, a certain amount of reaction which partially counteracts the propeller thrust and diminishes

Reprinted from *The Engineer*.

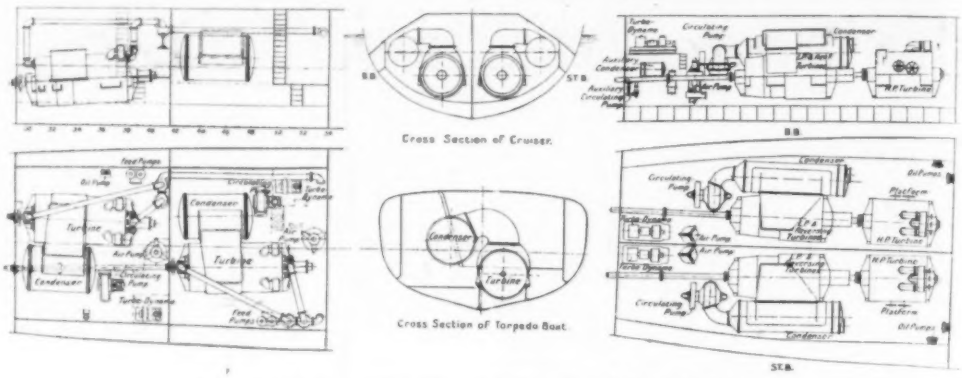


Fig. 1.—Turbine Arrangement in a Cruiser and Torpedo Boat.

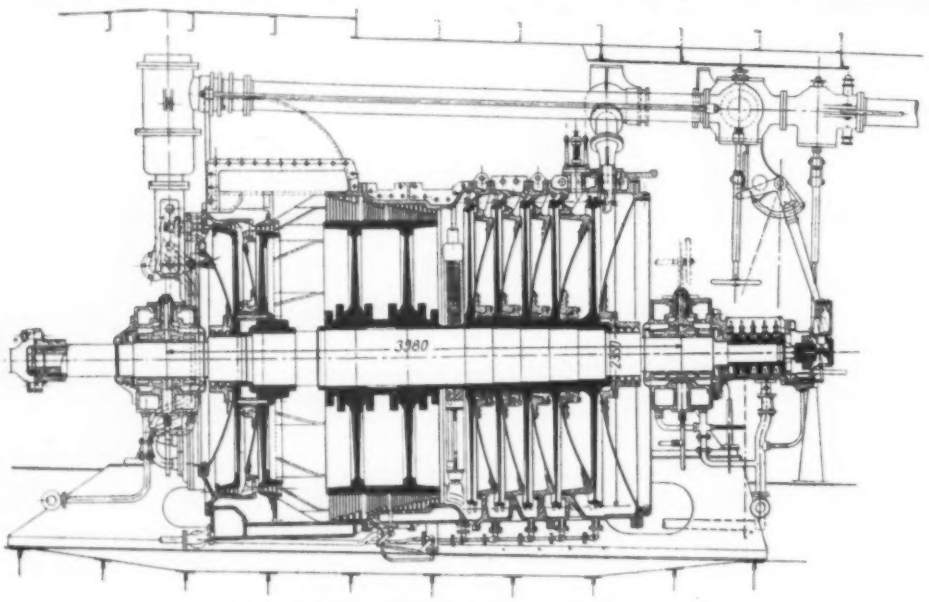


Fig. 2.—Turbine of Hamburg-American Liner "Kaiser."

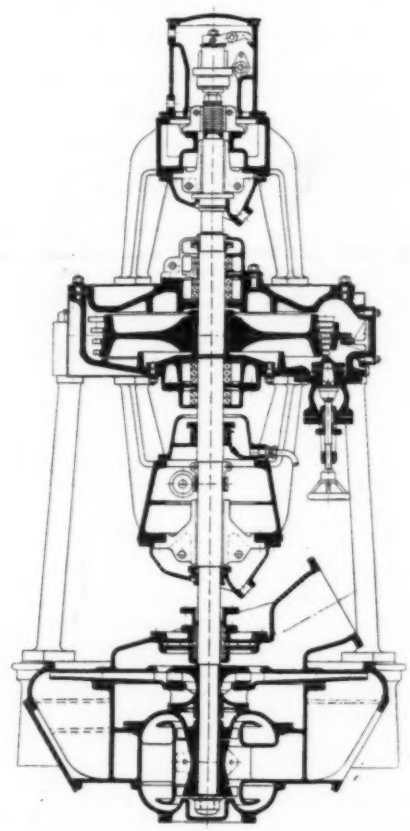


Fig. 3.—Turbine-driven Air Pump.

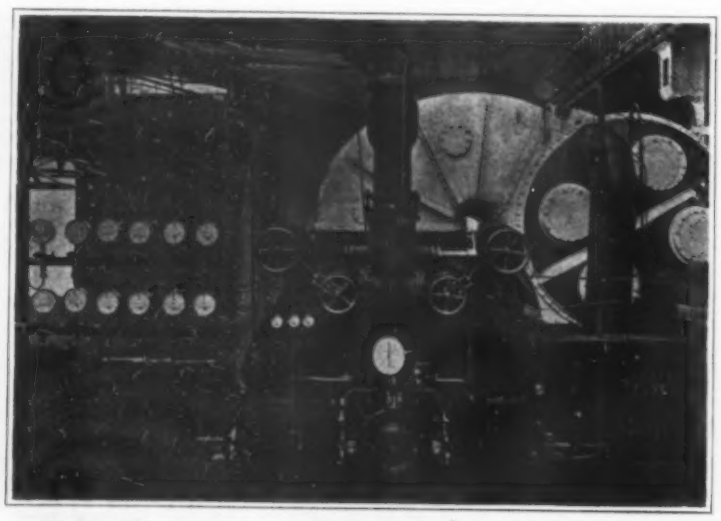


Fig. 4.—End View of A. E. G. Marine Turbine Erected on Test Plate.

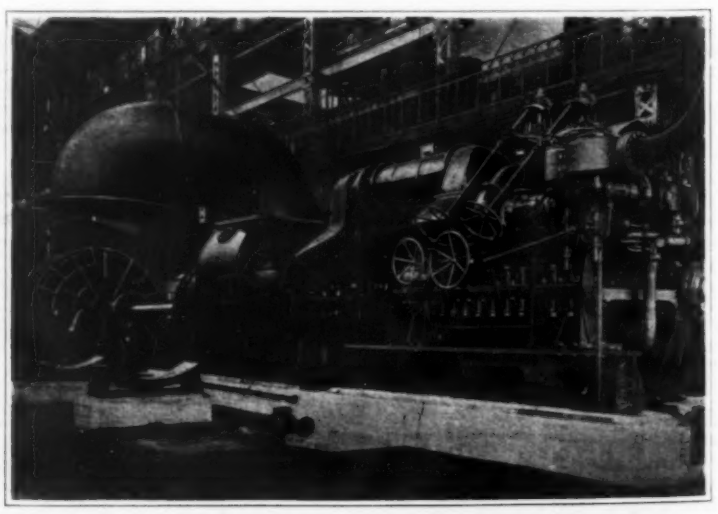


Fig. 5.—A. E. G. Marine Turbine and Water Brake—Condenser Removed.

Fig. 6.—Turbine for Torpedo Boat, Under Test.

the size of the propeller thrust blocks. As is usual with all turbines of the A.E.G. type, the blades on the wheels and also the nozzles, are made either of nickel steel or special bronze, the blades being caulked into the rim of the wheel and the tops riveted to a strip passing right round the circumference, as is now common with some types of blading for Parsons turbines.

In 1908 a torpedo boat, "V 61," was built for the German navy, equipped with A.E.G. turbines, each developing 6,000 horse-power at the guaranteed speed of 30 knots, the speed of rotation being 570 revolutions per minute. These turbines embodied several improvements in design which experience with the "Kaiser" had proved to be advisable. There are seven pressure stages in the high-pressure end of the turbine; while for the low pressure an action drum is employed, which, as previously mentioned, gives an end thrust tending to nullify the thrust from the propeller. The reversing turbine is housed in the same casing.

In designing turbines for naval vessels, great importance has to be attached to the question of an economical steam consumption at cruising speeds, and in reaction turbine installations it has been usual to provide special cruising turbines. In this torpedo boat two special cruising stages are provided in each cylinder, these being the second and third pressure stages. At cruising speeds, i.e., anything under 19 knots, the steam passes through the first pressure stage and then continuously through the second and third stages, which are provided with nozzles and blades designed for an economical consumption of steam at the relatively low speed of revolution. For vessel speeds over 19 knots, the two cruising stages are by-passed by means of the two pipes and valves seen in the illustrations, so that the steam, after passing through the first stage, immediately enters the fourth without going through the second and third. It may be mentioned that the weight of each of these turbines was only 28 tons.

The disposition of the machinery in an impulse marine turbine installation differs considerably from that with Parsons turbines, as is seen from the drawing on the left of Fig. 1, which shows the arrangement adopted on the "V 164," which may be taken as the standard design for torpedo boats equipped with A.E.G. turbines. There are two turbines separated by a transverse bulkhead, and each engine-room is self-contained with its own condenser and circulating and air pumps, while there are also separate boiler feed pumps in the two turbine rooms.

The illustration, Fig. 4, shows an end view of one of these machines erected on the test-plate at the works of the A.E.G. Company, while a front view of the same machine, together with the water brake, is shown in Fig. 6.

The torpedo boats "V 162," "V 163," "V 164," which were built shortly after the "V 161," were also equipped with A.E.G. turbines, and were somewhat similar in design. The guaranteed speed was 30 knots, with a horse-power of 13,000, and it was found that at this power—650 revolutions per minute—the consumption of steam was 13.5 pounds per horse-power hour. The highest speed actually attained was 32.2 knots, when the turbines were developing 16,000 horse-power at 660 revolutions per minute. In these turbines no cruising stages were employed, there being expansion nozzles in the first stage which could be regulated as desired for cruising speeds.

Further torpedo boats of this type have been built by the Vulcan Company, of Stettin, who also construct the turbines under license.

The most important vessel up to the present which has been equipped with A.E.G. turbines is the small German cruiser, "Mainz," with a displacement of 4,350 tons and a contract speed of 25 knots. As usual, a twin-screw arrangement was adopted, the general disposition of machinery being shown in the drawing on the right of Fig. 1, from which it is seen that each shaft has a separate high and low-pressure turbine, with a bearing between them, the reversing turbine being in the casing of the low-pressure turbine. It will be noticed that this boat is of approximately the same displacement as the British cruisers of the City or Town class, of which one, the "Bristol," was equipped with Brown-Curtis impulse turbines, and it will be interesting to compare the performances of these vessels.

Great care was taken in the design of the turbines of the "Mainz" to provide for an economical steam consumption at various speeds, and to accomplish this, four cruising stages were provided in each high-pressure cylinder, these being the second to the fifth, inclusive. Up to 17 knots—or rather over, since the guarantees were well exceeded—all the stages are in operation; for speeds from 17 to 20 knots, the second and third stages are cut out by means of by-pass pipes and valves. For anything above 20 knots up to the top speed, all four cruising stages are cut out, and the steam is by-passed directly from the first stage to the fifth. The low-pressure turbine consists of impulse drums, the reaction from which is able to neutralize to a considerable extent the propeller thrust. The reversing turbines are in the same casing as the low-pressure drums, and consist of three pressure stages with an impulse drum on the end, this being necessary to keep the steam consumption within the limits required in order to give sufficient power when going astern. The dimensions of the turbines are interesting in comparison with those of the Parsons type. The high and low-pressure cylinders have the same outside diameter, which is about 9 feet, while the lengths of the turbines from center to center of bearings are about 12 feet and 18 feet, respectively. The illustration, Fig. 5, shows a complete turbine erected in the A.E.G. works for trials on the water brake which is seen on the left, the condenser being removed. In this illustration all the hand wheels operating the various valves are plainly seen.

One of the most important features in connection with the turbines of the "Mainz" is the fact that superheated steam is employed, which is quite unusual with marine turbines, particularly those of the reaction type. The degree of superheat in this case is between 80 deg. Fahr. and 100 deg. Fahr. for high powers, while at cruising speeds on long voyages it is often as much as 170 deg. Fahr. measured immediately behind the superheater.

Some very interesting experiments were made on the turbines at the A.E.G. works, and the results, as regards steam consumption, are summarized as follows.

	Test No. 1.	Test No. 2.	Test No. 3.	Test No. 4.	Test No. 5.
Boiler pressure, lb. per sq. in.	235	235	235	235	235
Superheat, deg. Fahr.	80	170	80	170	80
Vacuum, in.	25.5	27.8	27.8	27.9	27.9
Revs. per min.	325	244	244	206	206
B. H. P. of turbine	10,450	3950	3950	2075	2075
Steam consumption per H. P.-hr., lb.	12.1	13.2	14.4	15	15.6

Test No. 1 corresponded to a vessel speed of 25½ knots; Nos. 2 and 3 to 20 knots, and Nos. 4 and 5 to 17 knots. It will be seen that the steam consumptions are very favorable, being practically identical with those obtained with the reaction turbines in the vessels of the new Town class.

The effect of superheat on the steam consumption is well marked, and it is interesting to note that when the turbine was developing about 4,000 horse-power, an additional 90 deg. Fahr. superheat reduced the consumption about 6 per cent, while at the lower output of about 2,000 horse-power—for each turbine—the same change of superheat only caused a reduction of about 4 per cent of the steam consumption. On the official trials of the "Mainz," a speed of 27½ knots was attained, the total power which the turbines then developed being 27,300 horse-power.

The A.E.G. has also developed some new types of turbine-driven air pumps and boiler feed pumps which are now being extensively used on turbine-driven ships, and certainly possess great advantages over the reciprocating types in the matter of weight and space required. Figs. 7 and 3 show respectively a complete view and a sectional elevation of a combined wet and dry air pump, driven by a single steam turbine. To economize space, the machine is of vertical construction, though it is equally suitable for a horizontal design. The turbine consists of a single wheel, and the air pump is arranged underneath the cylinder, forming the bed-plate of the machine. Water passes into the center of the air pump between the vanes of a moving wheel, and thence through holes in the fixed guide vanes, causing a suction and drawing in the air which follows the path of the water. The water is used over and over again, being passed through a small cooler seen above the air pump.

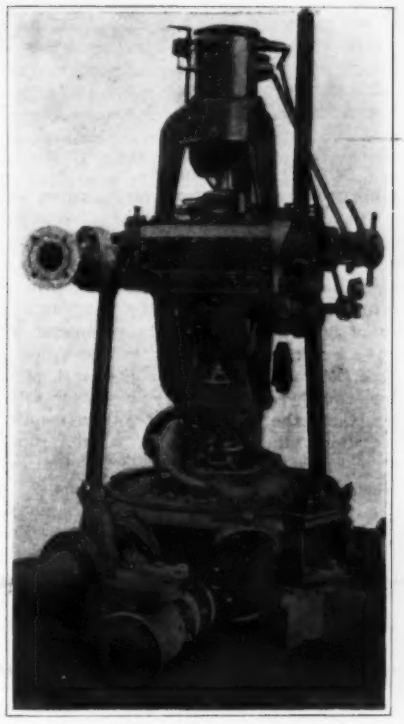


Fig. 7.—Turbine-driven Air Pump.

Electrical Steering.

IN a paper read before the recent meeting of the British Association for the Advancement of Science, Mr. P. K. Haigh discussed the advantages of electric power for actuating the steering gear of vessels. The following abstract is reprinted from the *English Mechanic and World of Science*.

Electrical steering offers considerable advantages for steamers as well as for vessels propelled by internal-combustion engines, for the improved economy corresponds to a saving of weight in boilers and fuel. Difficulty has been experienced in obtaining a reliable system of control, capable of dealing with the power necessary to put the helm hard over in emergency in the shortest possible time, and possessing sufficient sensitiveness to enable an accurate course to be kept by moving the rudder promptly in small angles. Sensitiveness is shown by absence of "time lag" between the movement of the hand-wheel and the corresponding movement of the rudder, and in this respect electrical gears promise an improvement on steam gears, whose economy is reduced when large control-valves are fitted. Sensitiveness also requires an absence of undue "idle travel" of the hand-wheel, but a certain small amount is nevertheless desirable. The steering motor may be started and stopped for every motion of the rudder, but it is preferably kept running continuously, mechanical control being introduced either in the form of hydraulic transmission or in the form of magnetic clutches. In the latter type of gear two magnetic clutches are employed, these being fitted at opposite ends of the motor; and, as no gearing is kept continuously in motion, the wear and tear, as well as the current required, are reduced to a minimum. The clutches prevent the shock of the sea being transmitted to the electrical system, and as they have considerable flywheel effect, the current taken by the motor does not fluctuate widely under normal conditions, and the steering gear may therefore be supplied from the ship's lighting generator. To economize power it is advantageous to arrange the gear so that greater leverage is obtained when the rudder is hard over than when amidships, and by doubling the leverage in this manner a saving of 30 per cent may be made in the motor power. Steering gear suitable for a 7-inch post, when tested against an artificial hydraulic load, developed a torque of 50 foot-tons at the rudder-post, and showed an efficiency of over 50 per cent at half load. It was found capable of moving the tiller through 70 degrees in 25 seconds, and responded to motions of the hand-wheel equivalent to 1 degree of helm.

The Goldschmidt Reaction*

Its Theory and Applications in Practice

By H. Stanley Redgrove, B.Sc. (Lond.), F.C.S.

1. SCIENTIFIC ASPECTS OF THE GOLDSCHMIDT REACTION.

IT was in 1898 that Dr. Hans Goldschmidt announced that he had succeeded in reducing the oxides of many metals very conveniently by the aid of aluminium. That aluminium should prove a most powerful reducing agent, readily reacting with the oxides of other metals with the production of much heat, is a result that might very well be expected from the fact that aluminium has a greater heat of combustion, and therefore possesses a greater affinity for oxygen than the majority of other metals. But like certain other substances which, capable of reacting exothermically (i. e., with the evolution of heat) with one another, will not do so until a certain amount of energy has been supplied to them from without, aluminium and metallic oxides will react with one another only at high temperatures. Earlier attempts, however, to bring about the reduction of metallic oxides by aluminium, by heating mixtures of these ingredients, proved very unsatisfactory; for either no reaction took place, not sufficient heat to start it being supplied, or else it occurred with explosive violence. Dr. Goldschmidt overcame the difficulty by an ingenious device. He found that intimate mixtures of metallic oxides and powdered or granulated aluminium, if heated strongly at one point, react with the production of intense heat, the temperature produced being far greater than that required to initiate the reaction. Consequently the reaction spreads throughout the whole mass, as a matter of fact doing so very rapidly, the time of reaction, which is about one half to one minute in the case of iron oxide and aluminium, not appreciably depending upon the quantity of material employed. The external heating necessary to start the reaction may in some cases be supplied by means of a strip of burning magnesium; or better, a fuse composed of aluminium powder and barium peroxide (which can be ignited by a flaming vesta) may be employed.

From the chemical standpoint the reaction is one of the simplest, thus, in the case of *iron* oxide it may be represented by the following equation:

$$Fe_2O_3 + 2Al = Al_2O_3 + 2Fe,$$

and similar equations can be constructed to represent the reactions in the case of other metallic oxides. The heat generated in the reaction between aluminium and iron oxide is sufficient to fuse both the alumina and the metallic iron produced, the whole contents of the crucible in which the reaction is carried out becoming fluid.

The metal, owing to its density, sinks to the bottom. The temperature reached is second only to that of the electric furnace, being estimated to be about 3,000 deg. C. The reaction can be very readily carried out, no apparatus beyond a crucible of highly refractory material being required. Care, however, should be taken to protect the crucible in case it should be cracked by the heat of the reaction, and its molten contents run out.

That substances apparently so inert as aluminium and iron oxide should be capable, once interaction between them has been started, of producing sufficient heat, not only to continue their own combustion, but to liquefy iron and even more difficultly fusible metals, may seem an extraordinary fact. But it is quite analogous to the behavior of a rock nicely balanced at the top of a hill. Leave it alone, and what could seem more destitute of energy; give it but a gentle push—and who shall stay its course?

By using other oxides in place of iron oxide Goldschmidt was able to prepare many other metals (in a fused condition). Moreover, providing that the oxide was present in slight excess of the amount chemically equivalent to the quantity of aluminium employed, the corresponding metal was obtained in a state of exceptional purity, free from carbon. By using mixtures of oxides, alloys of desired composition were similarly obtained. It seems, indeed, that practically all metallic oxides will react in this manner with aluminium. In some cases, e. g., titanium and vanadium, in which pure metals are not obtained, the product is sufficiently pure for the preparation of the chlorides. Even calcium oxide (lime) is not entirely proof against the activity of aluminium, though the reaction between these two bodes can only be brought about when they are heated together in a furnace, and is then by no means complete. It seems, therefore, to differ from the reactions between aluminium and other metallic oxides in being endothermic (i. e., heat-absorbing), and it may be concluded that calcium has a greater heat of combustion than aluminium (measured, of course, with respect to the same quantity of oxygen). Magnesia, however, is quite unattackable by this most active element. With alumina itself, aluminium yields a blackish-gray product, probably containing a sub-oxide.

Aluminium reacts in a similar manner with the sulphides of the metals. Thus, with galena (lead sulphide) the products are lead and aluminium sulphide, as shown by the following equation:

$$3PbS + 2Al = Al_2S_3 + 3Pb.$$

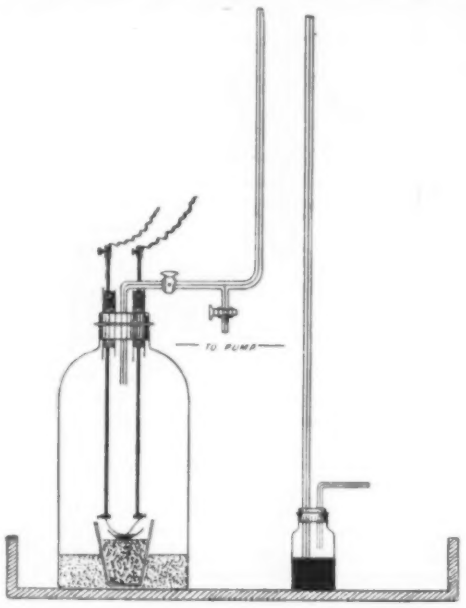


Fig. 1—Apparatus Employed by Weston and Ellis for Carrying Out "Thermic" Reactions *in vacuo*.

This reaction may be employed for the preparation of aluminium sulphide (which cannot be obtained in the wet way, since it is decomposed by water, giving aluminium hydroxide and sulphuretted hydrogen) which is obtained pure if the aluminium is present in slight excess. This excess of aluminium also serves to free the lead from any metallic impurities, for while aluminium will not alloy with lead, it readily alloys with many other metals. If aluminium were cheaper, the method might be used commercially for the extraction of traces of the precious metals from lead ores.

Aluminium will also react with certain non-metallic oxides (e. g., boron trioxide and silica). In the former case the product of the reaction contains aluminium boride and aluminium nitride (the nitrogen coming from the air) as well as alumina and free boron. In the latter case impure silicon is obtained as a crystalline substance containing aluminium. Aluminium will also react with charcoal; in this reaction the air seems to play an important part, the product containing aluminium oxide and nitride, as well as aluminium carbide (Al_4C_3) together with unchanged aluminium and carbon.

Fig. 2—Alumino-thermic Welding of Train Rails.

Since Goldschmidt's discovery, many other reactions, similar to those between aluminium and metallic oxides, in which substances other than aluminium are employed, have been described. Dr. F. M. Perkin, for example, has succeeded in bringing about the reduction of metallic oxides and certain other substances (e. g., galena and borax) by means of metallic calcium. Dr. Goldschmidt has also carried out experiments with this metal; he finds that it reacts with oxides in a most violent manner, but a regulus of metal is not formed owing to the limited fusibility of the calcium oxide produced. He finds also, that while silicon alone yields unsatisfactory results, a mixture of calcium and silicon reacts with metallic oxides in a satisfactory manner, giving a fusible slag of calcium silicate.

Another substance, behaving in a similar manner, is calcium hydride (CaH_2). Dr. F. M. Perkin finds that a mixture of this substance and cupric oxide (in the proportion of two molecules of the oxide to one of the hydride) can be readily ignited; volumes of steam are evolved and copper is produced, but the temperature is insufficient to melt the whole of the copper. A mixture of antimony sulphide and calcium hydride is also very easily ignited. As the reaction proceeds, the mixture swells up in a manner similar to that in which mercury thiocyanate ("Pharaoh's serpents") behaves when heated.

Messrs. F. E. Weston and H. R. Ellis have carried out a series of experiments on "thermitic reactions" (as these reactions are called) *in vacuo*. Their final form of apparatus is shown in Fig. 1. They found considerable difficulty in igniting the mixtures experimented upon, but this was probably due to the difficulty of producing a sufficiently high temperature *in vacuo*. They succeeded, however, in obtaining reaction *in vacuo* between magnesium and sodium peroxide and between aluminium and sodium peroxide by ignition with a platinum wire electrically heated; and by the use of the latter mixture as a fuse they succeeded in obtaining reaction *in vacuo* between aluminium and iron oxide. In air, one drop of water added to a mixture of aluminium and sodium peroxide causes it to react; but *in vacuo* they found it to cause merely a slight effervescence.

II.—TECHNOLOGICAL ASPECTS OF THE GOLDSCHMIDT REACTION.*

The technological importance of Goldschmidt's reaction can hardly be over-estimated. The whole subject is as yet in its infancy, but already it may be said to constitute a new branch of technology, to which the name of "Alumino-thermics" has been given.

In the first place, the reaction serves for the preparation of a number of pure metals and alloys of considerable value in the iron and steel and allied industries. Of the former of these we may mention chromium (98 to 99 per cent pure), manganese (96 per cent), and molybdenum (98 to 99 per cent). Chromium is used in the manufacture of high-speed tool steel, as well as armor plate; manganese is also used in the manufacture of very hard steel. Among the alloys we may mention chromium-manganese, manganese-titanium, ferro-titanium, ferro-vanadium and ferro-boron.

"Thermit"† containing a small amount of titanium oxide is used in foundry work. The mixture, placed in a tin fastened to an iron rod, is plunged into the molten iron as soon as it is run from the furnace into the ladle, and held at the bottom until the reaction is over. The slag rises to the top and can be removed. It is found that this treatment tends to prevent blowholes and to give clean, dense castings, the effect of the titanium being to increase the fluidity of the metal and produce a finer grain; moreover, the sulphur content is decreased.

In the slag from the reaction of chromium "thermit," minute rubies are found, ruby being nothing but crystalized alumina colored with chromium; but they are too small to be of any commercial value. A use, however, for the slag has been found. Dr. Buchner has discovered that, owing to its comparative freedom from metallic impurities and absolutely anhydrous condition, it is preferable to natural corundum (which it resembles) in the manufacture of pottery, for which purpose it is mixed with clay and burned, and is especially useful for making chemical apparatus which

* Reproduced from *Knowledge*.

* The writer's heartiest thanks are due to "Thermit, Limited" for their kindness in supplying him with full information concerning the technological applications of Goldschmidt's Reaction, for opportunity to examine their apparatus and methods, and for the loan of the half-tone illustration in the present article.

† "Thermit" is the registered name given to a mixture of aluminium and iron oxide.

may be subjected to great changes in temperature.

"Thermit" is also employed technologically as a heating agent. As Dr. Goldschmidt has pointed out, in "thermit" we have a new sort of fire differing in certain respects from all other fires. In the first place, in the combustion of "thermit" neither is air consumed nor is any gas evolved, as in the case of the combustion of such substances as wood, coal, coal gas or gasoline. The second difference is in the heat density. The actual amount of heat obtainable from a given weight of "thermit" is really much less than that obtainable by the combustion of the same weight of anthracite; but in the former case the whole of this heat is, so to speak, obtained at once, the reaction between large quantities of iron oxide and aluminium, as we have already indicated, occupying a very short period of time; indeed, by the combustion of "thermit" a heat density is produced unattainable otherwise. It is these peculiarities in its behavior which determine the applicability of the "thermit" fire. Where a continuous heating effect rather than density of heat is the essential desideratum, "thermit" would be useless; thus it is not suitable as a source of heat for locomotive purposes or for cooking generally. But where great density of heat is required "thermit" is preferable to other forms of fire, because by its aid one can so readily produce an enormous temperature at a moment's notice.

One of its chief applications as a heating agent purely is in the butt-welding of iron pipes. The ends of the pipes to be welded together are surrounded by a suitable mold, into which the products of the "thermit" reaction are poured. Welding temperature being reached, the ends of the pipes are pressed together by means of screws arranged in position beforehand. Of course, if the liquid iron produced in the reaction were allowed to come into contact with the pipes, they would be burnt through, but it is found, as a matter of fact, that the highly-refractory alumina slag, which issues from the crucible first on pouring out its contents after the reaction, solidifies on the surfaces of the pipes, thus forming a protective coating which is impenetrable by the molten metal.

In a method of welding which has been chiefly applied in the welding of tram lines, not only is the heat derived from the "thermit" reaction utilized to heat the lines to welding point, but the liquid steel produced is employed to form a bulb of metal holding the two lines together, thereby strengthening the joint.

An illustration of the method in use is shown in Fig. 2. The "thermit" is ignited in a crucible with a hole in the bottom fitted with a device for tapping. The molds around the rails are constructed in such a manner that the "thermit" steel, which first issues from the crucible when it is tapped after the reaction is over, runs to the bottom, forming a metal bulb over the joint to about half way up the rail or more. The metal, of course, must not be allowed to come in contact with the top of the rail. The molten alumina, which flows out of the crucible after the liquid metal, completely covers the top of the joint, and welding temperature being reached, the rails are pressed together by screws previously placed in position.

It is interesting to know that tests carried out on rails thus welded have proved very satisfactory.

It is clear from the hardness test that the subjection of the welded edges of the rails to the high temperature of the "thermit" reaction products has no injurious effect upon the hardness of the rail.

A somewhat similar method to the above is employed in welding third rails on electric railways.

The liquid steel produced by the "thermit" reaction may be employed in all sorts of repairs to iron and steel articles; and not only is it applicable to small articles but to work on the largest scale. Indeed, by the ignition of a couple of hundredweights of "thermit" one may produce in a few moments a hundredweight of super-heated mild steel, a quantity producible in so short a period of time by no other means. In repair work it is often found advantageous to add a certain proportion of steel punchings to the "thermit:" this reduces the quantity required and renders the reaction less violent.

Standards of Efficiency

The Basis of Comparison in Controlling Actual Performances

MR. HARRINGTON EMERSON, well known as "efficiency expert," has established a set of fundamental principles upon which he bases his system of reforms in commercial and manufacturing practice. One of these principles relates to the establishment of proper standards and schedules for every function to serve as a basis of comparison and as the ideal goal towards which the actual performance is to be made to approximate as nearly as possible. Mr. Emerson's discussion of this point, published in *The Engineering Magazine*, is full of interest not only on account of the extreme importance of the central thought on which it hinges, but also for the clever illustrations, gathered from all kinds of sources, which it contains. The writer says in part:

"Humming birds winter in Central America and nest in summer in Alaska, yet bring up families as beautiful, as courageous and as achieving as themselves. The stormy petrel flies four hundred miles through the fog and strikes its burrow exactly, storks marked in Norway have been caught in South Africa, curlew and plover are supposed to fly at the rate of four miles a minute.

"The barn-yard fowl, if frightened, runs and flutters over a low fence, and panting with exhaustion is soon run down. The rooster uses his wings to flap when he crows, the hen uses hers to brood her chicks, their ancestors having forgotten that they were birds and that the limitless air was their inheritance.

"Prof. Wm. James pointed out and insisted on the second wind, the ability that comes after the first fatigue, after the barn-yard flutter, to endure and achieve, to fly!

"Standards and Schedules! There are of two kinds, the physical and chemical standards discovered and established in the last century, standards and schedules as exact as mathematics, and those other schedules resting on standards whose upper limit we do not yet know. We have our five senses. We can taste or smell an infinitesimal taint in food, we can smell the millionth part of a grain of musk, we can discern by touch the ten-thousandth part of an inch, a man heard 2,390 miles away the boom of the explosion of Krakatoa, we see billions and billions of miles distant a new star bursting into brilliance; but there is a region not ten miles away about which we know less than we know of the nebulæ, because we cannot reach it without senses, nor yet with our physics and mathematics—a region ten miles or less straight down under foot.

"By bringing into play our instruments, our bolometers which measure the millionth of a degree of heat, our ultra-microscope which almost enables us to see the atoms, one one-millionth of a second measured on the tracing of a tuning fork's vibrations—by the refinements of physics and chemistry we can peer into the true inwardness of material things; so we use stop watches for time and motion studies of our machines; but when we wish to schedule work for sentient beings, then our mathematics fail and we fall back on experiments inspired by faith. Four miles a minute the flight of a little bird, 99 per cent and more the efficiency of the fire-fly's light, the sixth sense of the blinded bat, the sudden stop of the grizzly bear from full trot in darkest night when he was within a foot of the finest flower wire leading to a flash-light camera!

"All around us, everywhere nature has been showing us that increased result comes from lessened effort, not from greater effort, but we have been too stupid to understand. Because it takes one pound of coal to produce one horse-power, and two pounds of coal to produce two horse-power, because it is harder to jump over a fence four feet high than over a fence two feet high, because it is still harder to jump over a fence five feet high, we have non-reasoned back from results to effort, and concluded that effort should be gaged by result which is in accord with one set of experiences but wholly contrary to the larger experience. Any specific kind of effort, measured by results, falls from a maximum to a minimum and then rises again to another maximum, so there is only one point where maximum result is attained for minimum effort, a point properly scheduled at 100 per cent.

"As to specific result it may be attained in many ways. Tame geese in Germany are slowly driven to market in September, waddling a few miles each day. They are prepared for the trip by walking through soft warm tar and then through fine gravel and sand, so that, thus shod, their feet may stand the weary march. Wild geese fly from Golofnin Bay, Alaska, to the tropics in less time than the tame geese waddle a hundred miles. The wild goose's distance and time schedule would be ridiculous for the tame goose, the latter's schedule an absurdity not less cruel for the wild geese.

"This law of the reduction of effort for greater results crops up in the most unexpected places, so that engineers have evolved the definite critical speed, the speed of maximum result for relatively least expenditure.

"In fast steamers resistance does not increase with the cube of the speed, but there are certain higher critical speeds at which resistance is less. Nearly 100 years ago in England a man running express passenger canal boats had them towed by galloping horses at a speed of nearly 14 miles an hour, claiming this was easier than a slower speed. He was ridiculed by scientists who opposed the law of cubic increase of resistance. A bet was made, dynamometers attached, and up to 8 miles the law held good but above 8 miles the canal boat began to climb out of the water, so that at 14 miles the actual resistance was small. This was the origin of the hydroplane boat."

The influence of the total effort and some other factors upon the efficiency attainable is well brought out in the following table:

TABLE OF ATHLETIC RECORDS.

	One Mile.		One Hundred Miles.		
	Actual Speed.	Relative Speed.	Actual Speed.	Relative Speed	Relative to One Mile.
Amateur walking	9.2	100	4.8	100	52
Amateur running	14.	152	5.6	117	40
Amateur skating	21.8	237	14.	292	64
Amateur bicycle unpaced..	31.4	341	20.2	421	64
Professional bicycle paced	55.3	601	35.5	740	64

"It is known that each of these men put forth his best efforts, and assuming the men to be equal in strength, endurance, skill, we become certain that the mere addition of skates to the shoes increased the speed for the same effort 2.37 times at one mile and 2.92 times at 100 miles; that the substitution of a bicycle for skates increases the speed 3.4 times at one mile, 4.2 times at 100 miles; and that the addition of a helping pacer, who in no way touches the rider, merely shielding him from the wind, increases the speed above walking six-fold at one mile, 7.4 times at 100 miles. All these records are of abnormal, excessive, and extreme speeds, but who can doubt that the relation would remain the same if they were halved, thus brought down to high normal—4.6 miles for walking, 28 miles for paced bicycle?

"The time may come when aeroplanes rising on the wind as do the birds will glide on upward currents, as also do the birds, at a rate of two miles a minute for a thousand miles, or twenty-five times as fast as the walker, yet exert no muscular effort, using delicate instruments to feel the wind, and intelligence to guide the flyer.

"Other facts appear from the table. For the 100-mile stretch compared to the one-mile stretch, both bicycle and skating fall to only 64 per cent of the speed, but walking and running collapse respectively to 52 and to 40 per cent, so the man-used and man-driven tools not only vastly increase the speed, but maintain it at a far higher proportion. At one mile the paced bicycle rider is only six times as fast as the walker, at 100 miles he is nearly seven and a half times as fast.

"For physical, for chemical, and for electrical relations we can set absolute standards:

1 horse-power =

746 watts.
33,000 foot-pounds per minute
2,545 heat units per hour
0.175 pound carbon oxidized per hour
2.64 pounds of water evaporated per hour

"Practical standards are very different—one pound of coal in steam engines per horse-power hour, 10 pounds of water evaporated per pound of coal instead of 15!

"For physical standards we can measure the extent of the shortcomings and diligently strive to lessen the losses; but in making standards and schedules for man we must first classify our men, and then we must so equip them that they can as easily do six times, seven times—yes, perhaps 100 times as much.

"Walking 9.2 miles an hour is as to normal walking 200 per cent efficient, not a normal standard for any regular work, but compared to the effortless glide of the aeroplane it is only 10 per cent efficient.

"To establish rational work standards for men requires indeed motion and time studies of all operation, but it requires in addition all the skill of the planning manager, all the skill of the physician, of the humanitarian, of the physiologist, of the psychologist; it requires infinite knowledge, directed, guided and restrained by hope, faith and compassion.

"The promise already partly fulfilled and clearly held out as to the future is that greater and greater results shall follow constantly diminishing effort."

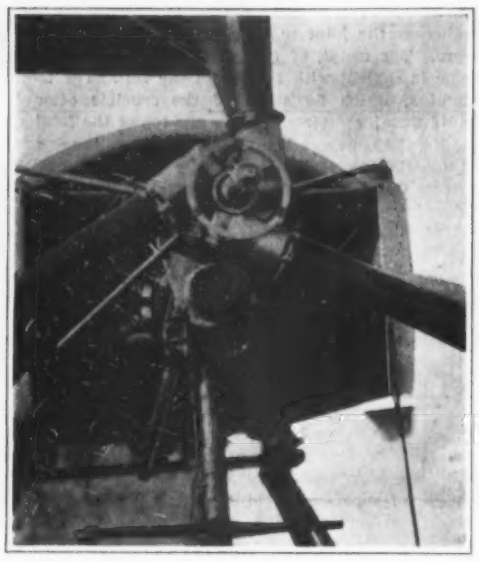


Fig. 1.—Gnome Motor and Breguet Propeller, Showing the Flexibly Mounted Blades and the Incased Reduction Gears.

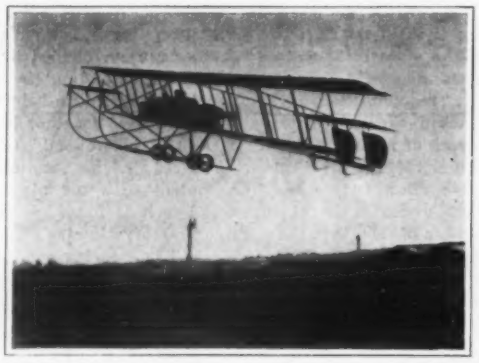


Fig. 2.—Barra in Flight on a Maurice Farman Biplane With Offset Planes.

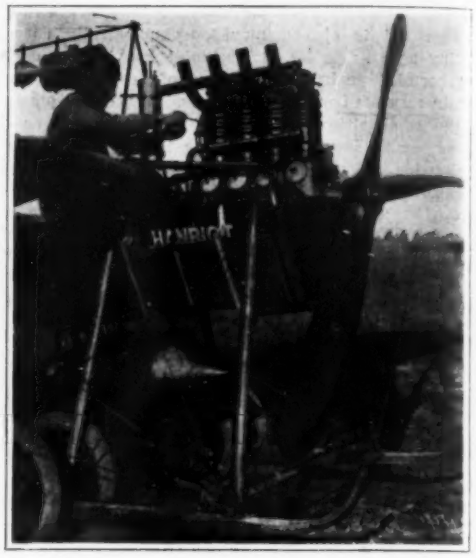


Fig. 3.—Front of Hanriot Monoplane, Showing 70-Horsepower Clerget Motor in the Boat-Shaped Body.

Results of Military Aeroplane Tests in France

Further Details of the Leading Machines Which Competed in the Contest

In the last number of the SCIENTIFIC AMERICAN we described some of the aeroplanes which competed in the great contest for military aeroplanes which has just been held in France. We give herewith details and photographs of some of the other competing machines, together with the results of the contest.

As we have already stated, the monoplanes came out triumphant in this test, although they were not so numerous as the biplanes, and although it was generally supposed that they would have great difficulty in landing and restarting from a plowed field on account of the speed required and the danger of capsizing. The Nieuport monoplane (a photograph of which was reproduced in the last issue of the SCIENTIFIC AMERICAN) was generally supposed to be a very difficult machine to start from rough ground, as its central skid, hung from the center of a flat leaf spring connecting the two wheels, is very liable to catch on any obstruction and to turn the machine on its nose. Grahame-White experienced this difficulty at the Brighton Beach Race Track last summer, but Weymann, on his 100-horse-power Gnome-engined Nieuport, seems to have had no trouble, either in alighting or starting from a plowed field, which was the most difficult of the three preliminary landing tests. Fig.6 shows him and his passenger in this machine, a spare wheel being carried in case of breakage. The Deperdussin monoplane was provided with wheels about three feet in diameter (900 millimeters), while the forward up-curved skids were dispensed with. As a result of these changes, no trouble was experienced with either of the two Deperdussins which were classed for the final. One of these machines was provided with a 100-horse-power Gnome motor, while the other, piloted by Vedrines, had only a 60-horse-power, 6-cylinder Anzani. Despite the fact of the smaller power, Vedrines, with a stationary Anzani motor, seems to have done better than Prevost, with a 14-cylinder revolving motor. The latter ascended to 500 meters (1,640 feet) in 9 minutes and 12 seconds, whereas Vedrines made the ascent to this point in less than 9 minutes. Prevost developed a speed of 108 kilometers per hour (67.10 miles), in the speed test from Rheims to Mourmelon and return. Vedrines started from a plowed field in less than 50 meters when carrying 302 kilogrammes of ballast. The Nieuport monoplane completed the climbing test in 10 minutes flat and developed a speed of 109 kilometers (67.72 miles) per hour in the speed test. With a machine that had been much used, Weyman completed the first day most of the tests without any difficulty; two of these which he completed were landing tests. He started from Rheims at 10 A. M., and landed at Monteornet. His machine was taken apart, towed 31 miles back to Rheims, reassembled, and at 4 P. M., he again started and effected a second landing upon the plowed field at Monteornet. Alighting again he once more made a start from the field, in order to show the capabilities of the machine. Weymann accomplished all the elimination tests with 40 kilogrammes (88 pounds) more fuel and oil than he needed. Each machine was supposed to carry enough gasoline and oil to fly 186 miles. Notwithstanding this extra load, he beat the record at the time by ascending 500 meters in 10 minutes. Weymann's machine is claimed to be the only one which was able to leave the plowed field without outside assistance other than that of the passenger whom he carried.

As it was generally supposed that only large biplanes would be able to carry the great dead load of 300 kilogrammes (660 pounds) required in addition to two passengers, the weight-carrying ability of the monoplanes was a surprise. Coupled with this, these machines also showed that they could start from and alight upon rough ground as readily as a biplane. In starting from such ground, they got away much quicker, as they generally were not provided with skids, which continually touched the high spots, when the elastics from which they were hung would give. In the matter of speed, the monoplanes were of course superior, although the speed that had to be attained—60 kilometers (37¼ miles) an hour was not beyond the reach of most of the biplanes.

The Hanriot monoplane is shown in Fig. 3. The machine which was entered in the test was provided with a powerful 4-cylinder 70-horse-power, Clerget water-cooled motor, carrying a propeller on the front end of its crankshaft. The radiator is shown on the side of the V-shaped body. This arrangement is similar to that used on the Antoinette monoplane. There is an extra fuel tank of considerable size suspended beneath the body. Twin wheels are also used with the double skids, whereas only single wheels had been used before. The spread of this machine is 13.6 meters (44.6 feet), and the total supporting surface 344 square feet. The weight carried was therefore 7 pounds per square foot. This also is one of the leading French monoplanes and one which we have previously described in the SUPPLEMENT.

When we consider the biplanes which were successful, the chief of these was the Breguet, three of which, fitted with a 100-horse-power and a 140-horse-power Gnome motor and a 110-horse-power Canton Unné, were classed in the final. The Savary biplane was a novel machine somewhat similar to the Breguet, in that it had the motor placed in front. The novel points about this machine are shown on the next page (Fig. 7). The motor is placed in front of the lower plane in about the position occupied by the aviator's seat in a Curtiss biplane. A large radiator is mounted directly in front of the motor. Two propellers in front of the planes are driven by chains from the motor, in the same way as on the Wright biplane. The aviator is placed at the rear of the lower plane. There is a central skid below the lower plane and twin wheels placed far apart, one pair on each side. In place of the tapering body used on the Breguet, there is a wide frame structure extending back and carrying a double-surface tail. The motor used is a 70-horse-power Labor 4-cylinder water-cooled engine. One of these machines fell with aviator Level, owing to the motor giving out. The machine struck some telegraph wires and fell to the ground, the aviator dying as a result of his injuries.

The undercarriage of the Breguet biplane is shown in Fig. 8 on next page. This machine was described in detail in the SCIENTIFIC AMERICAN of April 22d. The undercarriage shown is one of the most successful, and is usually fitted with three wheels, but in the one illustrated twin wheels are placed at the front just behind a spade-like skid. A steadying fin is attached to the inclined upright. A narrow radiator is placed on each side of the body. The Breguet biplane is notable for only three or four uprights connecting the main planes at the front. It is readily dismountable, and for this reason is excellent for military use.

The Goupy biplane, illustrated in Fig. 5, was the first in Europe to use offset planes. Two of these machines were entered in the competition, but neither of them was classed in the final. The machine shown in flight is a Maurice Farman staggered biplane, two of which were placed in the final competition. This machine is built along standard lines with the exception of the offset planes, the motor, an 8-cylinder air-cooled Renault, being placed at the rear of the lower plane and carrying the propeller on the extremity of the cam shaft. It was

Fig. 4.—Fischer and Passenger About to Land on a Plowed Field with a Henry Farman Biplane.

Fig. 5.—The Goupy Biplane was the First in France to Have Offset Planes. Note Ailerons at Ends.

Fig. 6.—Weymann on His Nieuport Monoplane Ready to Land Upon and Start from a Plowed Field.

SOME INTERESTING FRENCH MILITARY AEROPLANES.

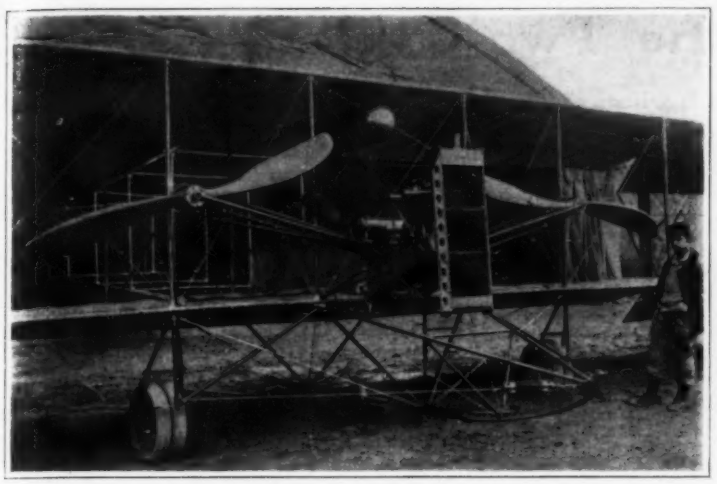


Fig. 7.—The Savary Biplane, Showing the Twin Propellers and 70-Horse-power "Labor" Motor in Front. Note Also the Twin Wheels and Single Skid.

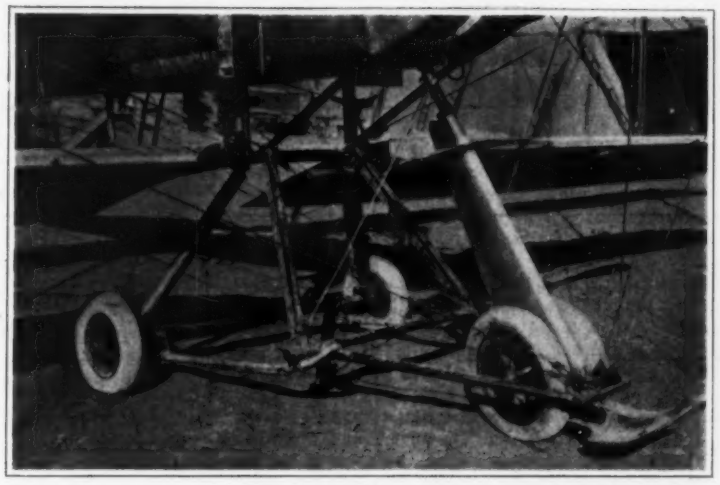


Fig. 8.—Center of Lower Plane and Undercarriage of the Breguet Biplane. The Steel Tubing Making Up This Chassis Is Flexibly Jointed at All Points of Intersection.

on a standard machine of this type that Reneaux won the $20,000 Michelin prize by flying from Paris to the Puy de Dome mountain and alighting thereon with a passenger last year. The standard Henry Farman military biplane is shown in Fig. 4, just about to alight on the plowed field. The upper plane of this machine has a spread of 67 feet, making it about the widest biplane that has thus far been produced. Only one of Henry Farman's biplanes was classed in the final competition. The machines which completed all the tests and were entitled to compete in the final race were as follows:

Monoplanes.

No. 35. Nieuport monoplane (Weymann) 100 H. P. Gnome motor.
29. Deperdussin (Prevost) 100 H. P. Gnome motor.
31. Deperdussin (Vedrines) 60 H. P. Anzani motor.

Biplanes.

No. 1. Breguet biplane (Moineau) 100 H. P. Gnome motor.
9. Breguet biplane (Moineau) 140 H. P. Gnome motor.
2. Breguet biplane (Bregi) 110 H. P. Canton-Unné motor.
3. Maurice Farman biplane (Reneaux) 75 H. P. Renault motor.
7. Maurice Farman biplane (Barra) 75 H. P. Renault motor.
20. Henry Farman biplane (Fisher) 70 H. P. Gnome motor.
21. Savary biplane, (Franz) 70 H. P. Labor motor.

The ten machines which constitute about one-third of all those which competed (thirty-one), finished all the tests successfully. These tests included three landing and starting tests on various kinds of rough ground, one speed test in which a speed of 60 kilometers an hour was required to be averaged with a full load, and two climbing tests, in which a height of 500 meters had to be attained in less than 15 minutes.

The final speed race of 300 kilometers cross country was not run on the 4th inst., owing to bad weather. Various attempts were made by the ten different machines on different days up to the 15th, but on November 13th Weymann won this event by covering the distance (186 miles) in 2 hours and 34 minutes, which corresponds to an average speed of 72.47 miles an hour. Prevost, on his 100-horse-power Deperdussin, was second in 3 hours and 17 minutes—an average of 56.6 miles an hour. Thus it can be seen that the monoplanes even were not able to approach this express-train speed of the Nieuport. The complete results of the final tests are not yet available, but we shall publish them shortly and comment upon them. We have already published drawings of the Nieuport monoplane in SUPPLEMENT No. 1852, and in the SCIENTIFIC AMERICAN of August 19th last. Drawings of the Deperdussin will be published in the next issue.

Bird Flight

By EVERETT H. BICKLEY.

MODERN aviation has drawn new attention to the mechanical explanation of various phases of bird flight.

It has long been known that the flexibility of the tips of the wing feathers in some manner makes soaring possible; but just what that manner is, has never been clearly explained. The explanation seems to me after careful study and experiment to be as follows: The flexible tips of the wing feathers act like the flap in a pump valve, which offers resistance to fluid motion in one direction and freedom in the other lessening the falling tendency and heightening the lifting effect of every variation in the air currents. From the following notes on the action of the wings during the wing stroke, the value of the flexible tips will be more readily comprehended.

In flapping flight the shape of the wing on the down stroke is shown in Fig. 1, and on the up stroke in Fig. 2. We also note that the wing is moved in an irregular path with relation to the bird's body, and not merely in an up and down manner. The path and action at different points is shown in Fig. 2. Since one vibration of the wings is completed in a small portion of space, we may disregard air-waves and disturbances for the analysis of flapping flight, and consider each vibration as being made in a homogeneous current. The disturbances of the air in a space smaller than that covered in one vibration of the wings, may be considered as acting in similar way to soaring flight.

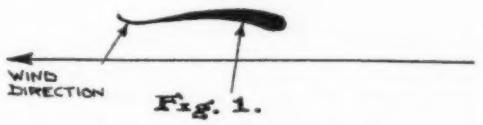


Fig. 1.

Wing Form in the Down-stroke.

The down stroke of the wings is the working stroke giving the lifting and propelling force. In general the lifting force is given by the forward portion of the wings, the propelling by the deflected tips. The first part of the up stroke is merely recovery, the wing being raised so that there is no air pressure exerted other than mere friction. This gradually changes into a sustaining position, until the excess velocity created by the previous down stroke has been expended; the wing then begins another down stroke, and new velocity and altitude are acquired. The variation in velocity during the different

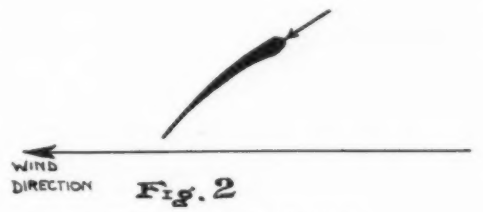


Fig. 2

Wing Form in the Up-stroke.

parts of the stroke can be easily seen with some birds.

The cycle of changes in pressure on the wings take place in soaring flight, with the exception that the wind and not the bird makes the motions. It is possible therefore to soar against the wind, just as easily as with it, the only difference being that the velocity relative to the earth is much greater in the latter case. A short rising current corresponds to the down stroke of the wing, and a falling current to the up stroke. The summation of all the rising and falling currents being zero, they must be equal in amounts. There must be therefore a rising current corresponding to each falling current, and those smaller ones which the bird utilizes cannot occur very far apart because of the elasticity of the air. The average velocity of the bird with regard to the air, carries the bird continually into different currents. The larger the atmospheric waves, the greater must be the velocity of the bird in order to obtain the succession of changes with sufficient rapidity to keep up the momentum. The velocity with which the bird can elevate himself depends upon the rapidity with which these irregularities follow each other. During the time the bird encounters a rising current, velocity and altitude are acquired. When the bird encounters the corresponding falling current, after the momentum acquired from the rising current has given out, it uses the excess velocity for sustention merely, until the next rising current is encountered. The bird by using its inertia and upward currents, lets the downward puffs slip past with very little effect. When the bird is flying in a section of air that is falling generally, the bird may either continue in this current until the air begins to move horizontally, or direct its course to take it into an ascending current of air, and continue in this current by circling, until the desired altitude is reached. The difference in the expenditure of energy in flapping and soaring flight may be compared to the difference between attack and defense. Since the wing muscles are alternately under tension and relaxation, there is a certain amount of fatigue that accompanies soaring, though not so great as that accompanying flapping flight.

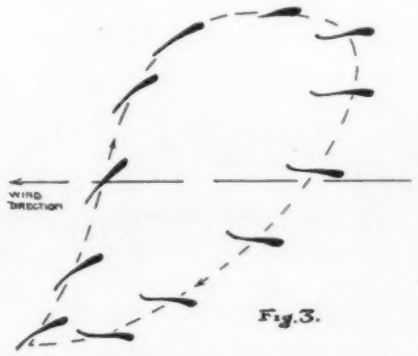


Fig. 3.

Wing Forms in One Complete Cycle of Strokes.

It is a common experience in aviation that the air is more irregular on days when there is no well-directed current. As soaring depends upon the irregularities, and not the velocity of the air, the soaring capabilities manifested by certain birds on days when there seems to be no current, is easily understood.

Photographing Corpses for Purposes of Identification

IN criminal cases it is often essential to place on record the nature of the wounds of a murdered person, so that the case can be discussed on reliable evidence at any time. Obviously, however, it is only in exceptional cases that it is possible to preserve the evidence in actual fact; in all other cases a photographic record can be used.

The photographic image reproduces all details with absolute accuracy, and incidentally is less repulsive than an anatomical preparation. Thus, for example, as has been shown over and over again in practice, it is possible from such picture to recognize exactly the form of the weapon which was used for the crime. Then again corpses, even if only a few days old, are often unrecognizable even by their own relatives. The difficulty arises through the fact that the expression of the eyes and the natural complexion is lacking. In the case of drowned persons, the swelling of the head and body adds to the difficulty of identification. Here again photography is very helpful. Such corpses are restored to lifelike condition by injecting glycerine into the eyes and vaseline into the lips, while the lips and cheeks are touched up with red paint. A photograph is then prepared of the face thus restored. Corpses which have lain in water for a very long time are rendered recognizable by massaging the skin with tallow and inserting glass eyes. Nikolo Minovici, of Bucharest, in all cases inserts glass eyes and imparts to the face any desired expression by fixing the facial muscles with needles, such as are used for mounting insects. Corpses washed up on the bank are restored to normal condition by pressing the skin, after having made a cut in the neck.—*Umschau.*

Large Gas Engines of the Two-Cycle Type*

By A. E. L. Chorlton

THE two-cycle engine was brought out by Mr. Dugald Clerk in its single-acting form some thirty years ago, but it did not prove successful commercially against the Otto four-cycle type in the small sizes then used. The demand for engines of very large power which sprang up after the successful utilization of blast-furnace gas, resulted in the development of the Oechelhauser and Körting double-acting two-cycle engines and these were found suited also to the use of producer, cokeoven and other gases.

Fig. 1 shows the arrangement of the original Körting engine with a double-acting cylinder, the exhaust ports in the center and air-inlet valves at each end, the separate gas and air pumps and the connecting passages. In this engine the exhaust begins by the piston opening the exhaust ports at 45 degrees before the center; the inlet valve then opens, admitting air which sweeps out the exhaust products; the mixture follows later, the exhaust ports being closed by the piston 45 degrees after center, followed by a short period of further charging, after which follow compression, ignition before the center and then the expansion. Thus in two full strokes the whole cycle is performed.

The Oechelhauser engine (Fig. 2) consists of a long cylinder open at both ends, having mutually opposing pistons working therein, with a combustion space intervening, and at their nearest positions containing the charge at the point of maximum pressure. The front piston is attached in the usual way to the middle crankpin, and uncovers a ring of exhaust ports or slots near the end of its out stroke. The back piston is coupled to the outer crankpins by means of a back crosshead, two side return rods, etc., and uncovers two rings of admission ports just before the end of its out stroke one for air and the other for gas. An extension of the back crosshead works a double-acting pump, one side of which supplies the gas and the other the air charge to separate receivers surrounding the cylinder.

The exhaust ports are uncovered a short time before the air admission ports, thus relieving the pressure in cylinder and permitting the influx of air and then of gas from the receivers at 5 to 7 pound gage pressure. The air admitted before the gas ports open effectively scavenges the cylinder; the mixture is formed while the gas ports remain open, when air

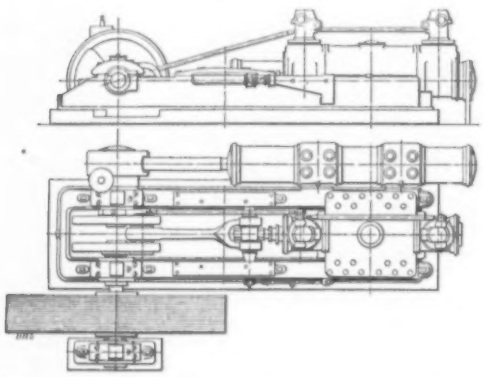


Fig. 3.—The Mather & Platt Two-cycle Körting Type Engine.

and gas enter with intimate contact. Thereafter the pistons commence to return, and the gas, air and exhaust ports close in succession. The charge at the beginning of compression is thus divided into three portions: (1) At the exhaust end scavenging air more or less mixed with the burnt gases of the preceding explosion; (2) an intermediate mixture of gas and air, or the charge proper; and (3) a cushion of air at the admission end, admitted after closure of the gas ports.

The largest single-cylinder gas engines in the world are a number of 2,000-B.H.P. blowing engines of the Körting type, built by the Siegener Maschinenbau, Siegen, Germany. They have the following dimensions: Stroke, 55 inches; cylinder diameters: power, 43 inches, blowing, 100 inches; speed, 30 to 90 revolutions per minute; normal load, 35,000 cubic feet per minute at 11.76 pound gage pressure. The valves are 19.7 inches diameter, have a lift of 3.14 inches and operate at 90 strokes per minute without noise. They are driven by means of rods coupled to cranks in the side shaft, the movement being imparted to the valves by means of rolling levers.

* Abstracted from a paper read before the Manchester Association of Engineers, Feb. 25, 1911. Illustrations reproduced from *Engineering* and *The Mechanical Engineer*.

A 2,500-B.H.P. single-cylinder Oechelhauser engine, built by W. Beardmore & Co., Glasgow, has a 48-inch cylinder, a stroke of 60 inches and runs at 80 revolutions per minute.

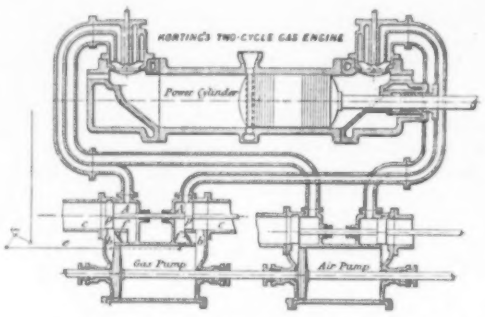


Fig. 1.—Arrangement of the Original Körting Engine.

An engine which will be described with some detail, is of the two-cycle type, Körting patent, as modified, simplified and improved by the firm of Mather & Platt, Ltd. (Fig. 3). After an extended investigation of all types on the market, the Körting was finally selected, as it possessed the following advantages: Every stroke a driving stroke; small size of cylinders; absence of exhaust valves; lightness of foundations; perfect scavenging; accessibility for cleaning; ease of

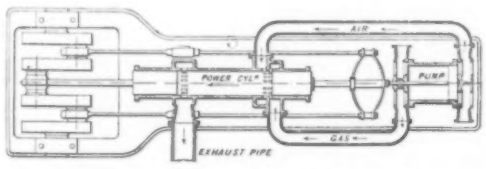


Fig. 2.—Arrangement of the Oechelhauser Engine.

starting up; steadiness of running; lightness of flywheels; possibility of running at reduced speeds; simplicity of valve gear; ability to work with a heavy suction without reduction of power.

The cylinder (Fig. 4) is double-acting and the front end of the piston rod is connected to an external crosshead. This, in connection with the long piston, insures smooth running inside the cylinder.

The double-acting pump for the gas is placed between (and in line with) the two single-acting air pumps (Fig. 5), valve boxes, which are divided by diaphragms into passages for gas and for air, separating the cylinders from each other.

When the cylinder pressure falls to atmosphere, the admission valve opens and the air pump forces scavenging air through the cylinder.

The gas pump now forces gas which mixes with air from the air pump above the inlet valve and enters the cylinder as the charge for the power stroke. The exhaust ports are closed by the return stroke of the power piston during the charging, and the mixture is then compressed and ignited electrically at two distinct points. The same cycle is repeated at each end of the piston alternately, and the thorough scavenging prevents pre-ignition of the incoming charge.

There are three general methods of constructing the frames of large engines, as shown in Fig. 6. Method *A*, or the concentric type, is favored by makers of four-cycle double-acting engines on the continent. Method *B* is an English design, originated by Messrs. Crossley. Method *C* is the one adopted by Mather & Platt. In this design the two main beams carrying the main bearings at the forward ends are continued rear-ward underneath projecting hollow brackets of the cylinder itself; thus the engine has one whole frame for its full length bearing all along on the foundations; by this means great solidity and freedom from vibration are obtained. The beams at the front end are tied together by angle pieces cast with them, the other end being held rigid by the bolting on of the main cylinder itself. The passages for conveying the gas and air from the charging pumps to the inlet valves are incorporated in the cylinder casting. All the machine work on the main beams, with the exception of boring the bearings, is done on a planer at one setting. The boring is accomplished by a portable boring rig.

The two types of cylinders generally used in double-acting engines are the Nürnberg (No. 1) and the Körting (No. 2), as shown in Fig. 7. In the Nürnberg type all the valve entrances are cast in one with the cylinder and the cylinder covers are of plain cylin-

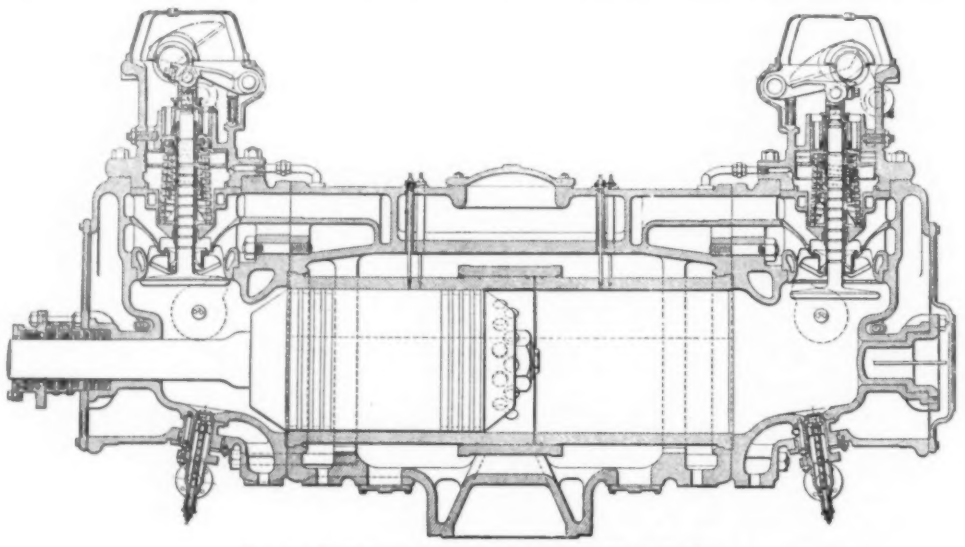


Fig. 4.—Section of Cylinder, Mather & Platt Engine.

drical jacketed form. In the Körting type, which was chosen, the cylinder is kept distinct in itself and the covers carry the valve pockets. A crack around the valve in the No. 1 type will destroy the cylinder, while with the No. 2 type only a new cover is required. The latter construction allows the use of a metal suitable for the cylinder, and also another mixture to care for the high stresses in the combustion chamber. Fig. 7 (No. 2) shows the liner used; this is of special hard iron, divided circumferentially at the

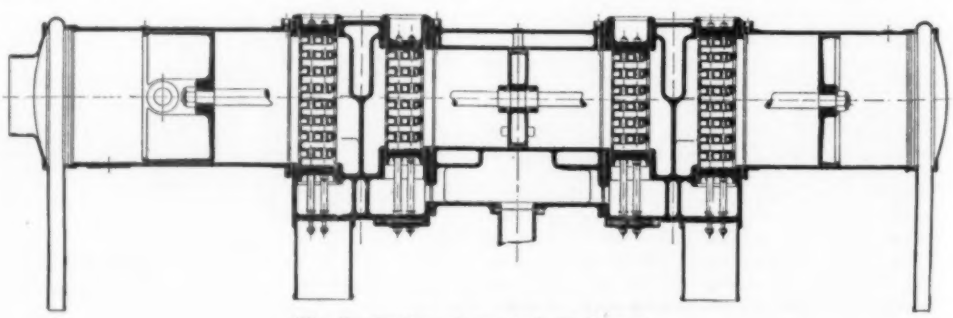


Fig. 5.—Section of Gas and Air Pumps.

middle into two parts to allow for expansion. The heads, shown in detail in Fig. 4, are steel castings, and are designed to allow for expansion when cooling after casting, also when at work, thus avoiding internal strains. Ignition plugs are fitted in the side of the cylinder heads in duplicate, placed directly opposite to each other, thus incidentally allowing of testing in position.

As only the admission valves have to be operated, the complicated, noisy and expensive cam-shaft drive has been dispensed with. The valve drive used consists of a simple eccentric on the crankshaft driving direct through a rod on to a pair of "crocodile" or rolling levers on the front inlet valve, the back inlet valve being driven from these by a short connecting rod. The inlet valves are of the plain mushroom type and have suitable air dashpots to ease their return on to the seat.

The crankshaft, shown in Fig. 8, is of the built-up type. The combined crank and balance weights are of cast steel, the other parts being plain bar forgings. The necessary grip is obtained with a shrinkage allowance of 1/600; to stand this shrinkage the web is kept very deep around the pins.

The crosshead, shown in Fig. 9, is designed to allow of easy and accurate machining. The crosshead pin is hollow and conducts the cooling water from one pipe of the double trombone, secured to an extension at one side to the hollow piston rod, and thus to the piston; the return comes through an internal tube back to the other pipe of the trombone.

The piston, Fig. 10, has a white metal bearing shoe underneath, and is supplied with eight rings. In the larger sizes the ends are of cast steel; the body alone being of cast iron. This allows of better cooling through the thinner walls, increased strength, and easy renewal of the body, if necessary.

The governor is exceedingly simple and effective. In principle it is a by-pass governor, a movable wing valve controlled from the governor (direct-driven from the crank-shaft) allowing more or less of the charge in the gas pump to be by-passed to the other end, thus regulating the amount going forward to the main cylinder according to the load.

To effect ignition, trip magnetos, with leaf-spring returns, are used. The point of ignition is effectively controlled by a small trip arrangement, consisting of a reciprocating plate carrying trip pieces which catch and move the magneto armature, the release of which is controlled by an adjustable wedge. The point of ignition can be easily varied by a hand wheel.

Large gas engines have been most generally used for the direct driving of dynamos or alternators, successful parallel running being now quite easily obtained, either with other gas sets or steam-operated plants. Probably the most important application of large two-cycle engines is for blowing work for blast furnaces, the blowing cylinders being placed tandem, and operated through an extension of the piston rod. In this work it has proved very successful owing to the large speed variation possible, giving a range down to one-quarter maximum speed. The speed reduction may be effected automatically by the pressure in the main air receiver acting on a suitable valve.

Several gas installations have been made in textile mills by Messrs. Mather & Platt, Ltd., one of them being shown in Fig. 11. This plant was erected in existing buildings, replacing a steam engine. The gas generating apparatus is of the Power-Gas Corporation suction type, burning low-value Scotch anthracite coal. The engine drives the line shaft by means of ropes from a pulley on the crankshaft without the intervention of clutches, etc., for starting. The power is absorbed in driving machines used for weaving and calendering linen fabrics, and also in driving a dynamo for lighting the mill. The exhaust gases are passed through an exhaust-heat boiler which provides sufficient steam for the sizing and calendering machines and the heating of the weaving sheds. The owners state the fuel consumption to be 1.16 pounds per B.H.P.-hour, including all standby, meal hours, nights and week-ends at ¾ load, equal to about 0.9 pound full-load running.

Exhaust boilers serve to utilize the waste heat of gas engines. To be efficient they should be located as near the engine cylinder as possible and be made and maintained absolutely water-tight, as any leakage means rapid corrosion from the sulphuric acid formed from the exhaust gas. Economizer pipes for preheating the feed should be of cast iron. The evaporation of an exhaust boiler can sometimes be made to exceed 3 pounds per B.H.P.-hour. The boilers are usually from 6 to 7½ feet long between the tube plates and the total flue area in square inches is made equal to 0.8 of the cylinder capacity in B.H.P.

Fig. 12 shows an ordinary multi-tubular boiler arranged close to the exhaust of a two-cycle double-acting engine, and heated by the exhaust gas alone. Fig. 13 shows an arrangement having a separately fired grate, in addition to the exhaust heated part. This class of boiler is specially suitable for intermittent running of the engine, as in cotton mills, etc., where, if the exhaust steam is used for heating the mill, the supply can be kept up by a separate fire over the week-end, etc. On the fire ordinary coal may be used, or it may be arranged for gas or tar firing.

Experiments have determined that the economy of the gas engine working on the principle at present used, cannot be materially increased; the question of its evolution must therefore be looked at from other points of view. The author is inclined to predict considerable expansion in the use of the two-stroke type. If the first cost of the engine can be brought down near that of a similar steam engine, there will undoubtedly be a much greater development.

Efforts in this direction mean the use of lower compression pressures, etc., in order to reduce the weights and strengths at present required. The reduction of compression and maximum pressure means, of course, an increase in gas consumption, and this of itself is scarcely advisable; but if there is added to such an engine an improved method for utilizing the waste heat of the jackets and exhaust, the original economy is the recoverable. Such a design involves the addition of an exhaust boiler and a simple, but highly efficient, steam cylinder. With such a combination,

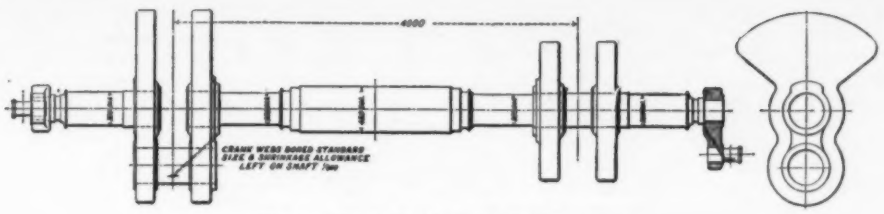


Fig. 8.—Crank Shaft of the Built-up Type.

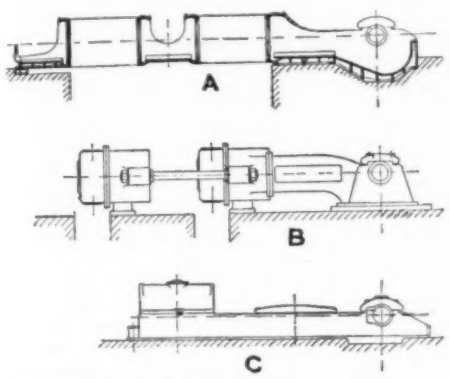


Fig. 6.—Types of Frames for Large Engines.

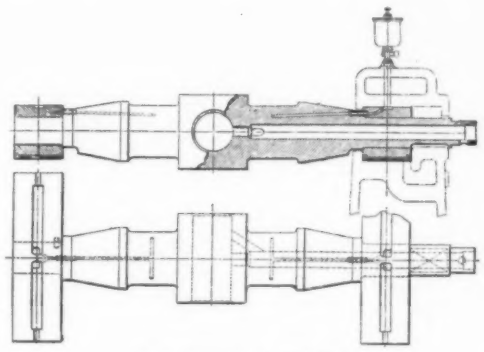


Fig. 9.—The Crosshead.

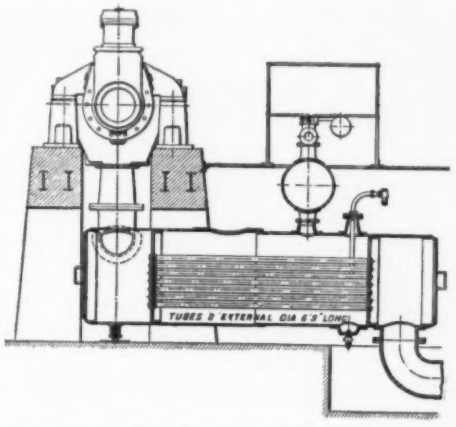


Fig. 12.—Boiler Heated with Exhaust Gas.

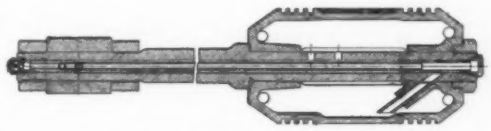


Fig. 10.—Section Through Piston.

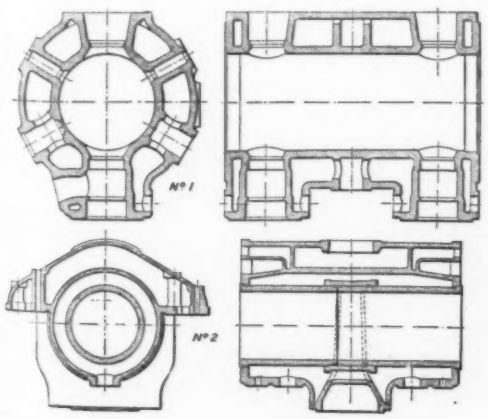


Fig. 7.—Types of Cylinders for Double-acting Engines.

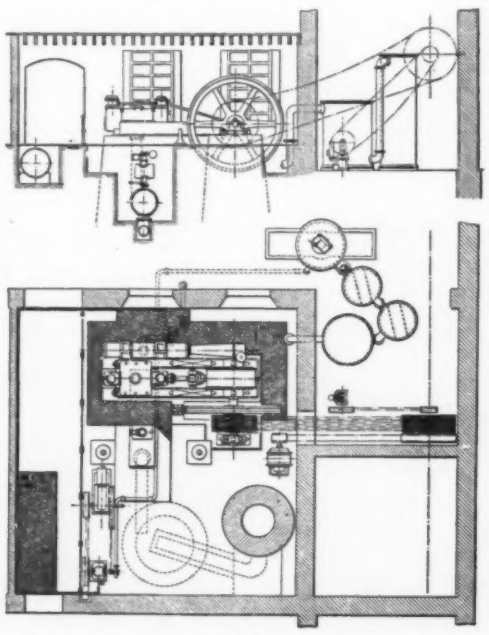


Fig. 11.—Gas Power Installation in a Textile Mill.

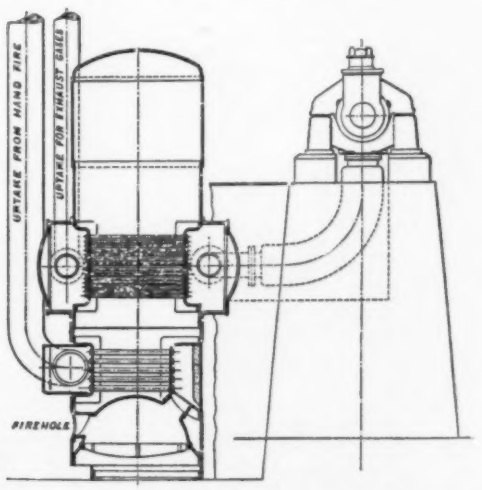


Fig. 13.—Combined Exhaust-Gas and Grate Firing.

using a much lower pressure than now, the total B.T.U. per B.H.P.-hour would probably be about 12,000. With a special arrangement of boiler, economizer pipes, superheaters in exhaust, etc., 50 per cent of the waste heat should be recoverable. Taking the efficiency of conversion at 80 per cent, four pounds of steam should be generated per B.H.P. of capacity ($12{,}000 \times 0.50 \times 0.80 \div 1{,}185 = 4$). The steam cylinder used would be similar in type to that of the two-cycle gas engine —i. e., with no exhaust valves, and similar to that of the Stumpf unidirectional engine (see page 32, *Industrial Engineering*, July, 1910), the jacketing of the ends being done by exhaust gas. Such a cylinder will give 1 B.H.P. from 12 pound steam. This gives a power from the steam cylinder of one-third that of the gas cylinder, and consequently reduces the consumption for total effective power to 9,000 B.T.U. per B.H.P.-hour, or less than for the economical gas engine alone, which require 9,500 B.T.U. per B.H.P.-hour.

The total cost should be less, for we have, taking approximate prices [English.—Ed.] of gas engines at $25 per I.H.P. and steam engines at $15, three-quarter gas engine at a reduced cost (lower pressures), say, $20 per I.H.P., one-fourth steam cylinder (less special crank and valve drive, but including exhaust boiler) at $15. The approximate comparison then per I.H.P. is: Gas engine, $25; steam engine, $15; compound engine, $18.75. A gas engine with an auxiliary steam cylinder has other advantages outside economy. It is an excellent method of starting the engine, or for marine work for reversing, and it provides a means for the gas engine taking a considerable overload, so that considerable progress may be looked for in this direction in the near future, as well as in other and more novel forms, as the Humphrey, turbine, Brayton engines, etc.

The Distribution of Luminosity in Nature

IN a paper read before the Illuminating Engineering Society Messrs. Ives and Luckiesch gave some interesting data regarding the distribution of light in nature, and its effect upon our eyes. An abstract of this paper, prepared by Mr. Ives, has appeared in the *Electrical Review and Western Electrician*, and is reproduced here. The writer says:

"The distribution of luminosity has been studied by means of photographic plates whose sensitiveness to lights of different color has been made similar to that of the eye by superposing a screen having the proper absorption. It is thus found possible to obtain a curve representing the sensibility of the plate at different wave lengths which almost exactly duplicates a similar curve for the eye. Such plates were exposed to various landscapes and street scenes, and the intensity of the illumination reaching the camera from different angles was measured by the density of the plate. Two exposures were made, one in the customary way, the second with a cylinder of glass placed before the lens. This cylindrical lens threw the focus out horizontally, but not vertically, the result being to average the vertical distribution of brightness. Curves have been plotted for eight cases showing the amount of light which will enter the eye from different vertical zones and these plots have been compared with the general impression of the view made upon the observer as regards comfort and pleasure given. The authors conclude that the eye tolerates greater brightness above the horizontal than below. The presence of large areas of uniform high brightness are an unpleasant feature. Pleasing landscapes are those with a preponderance of brightness in the sky and the foreground showing marked varieties of light and shade. Measurements of the illumination made at the same time showed that blue sky gives about 0.2 candle per square inch, a cumulous cloud 10.4 candles per square inch. On a dark, overcast day the brightness of the sky fell to 0.1 candle per square inch. The cement pavement in sunlight gave 6.0 candles per square inch. The ratio between the brightest and darkest point of the average distribution in the most varied landscape is about twenty to one."

Engineering Notes.

Small Wastes on Railways.—A somewhat amusing but instructive method of drawing their employees' attention to the effect of small wastes is adopted, according to the *Railway and Engineering Review*, by the Pere Marquette Railroad. A table has been drawn up by the company showing that for every postage stamp needlessly used the railway has to haul one ton of freight a distance of 3½ miles to recoup for this waste. For a lead-pencil the haul is two miles; a track-spike, 2 miles; 1 pound waste, 10½ miles; a lamp chimney, 10½ miles; a station broom, 35 miles; a lantern, 100 miles; track-shovel, 90 miles; 100 pounds of coal, 20 miles; 1 gallon engine oil, 50 miles; 1 gallon signal oil, 60 miles; air hose, 225 miles; drawbar knuckle, 300 miles.

Trade Notes.

Glue for Gluing Leather Articles.—To ordinary glue, some alum is added. The glue thereby not only acquires greater capacity for resisting the effects of moisture, but becomes flexible and is consequently better adapted for gluing saddlery goods, straps, etc. —*Ledertech. Rundschau.*

Black Glaze for Clay Goods.—The clay must be polished with a hard, smooth substance (agate or glass). It is placed, enveloped in sawdust, in a large vessel and introduced into the kiln to ignite the sawdust. Before the charcoal produced by the burned saw-dust is entirely consumed, the vessel must be taken out and cooled.

Waterproof Cement for Fine Earthenware Goods.—Twenty parts of white lead and 12 parts of pipe clay, that has been carefully dried, are stirred into 10 parts of linseed oil varnish and heated in the water bath, the mixture being well kneaded together. The articles cemented with the compound must be slowly dried in a warm place.

Distemper Painting.—(a) The yolk of egg should be thoroughly mixed with linseed oil or varnish, so that both are intimately combined; thin suitably with water. To one egg-yolk add 20 to 25 drops of oil (possibly a small addition of alcohol). Avoid chalky ground. (b) 2 parts egg-yolk, 4 parts vinegar, 1 part good matured linseed oil varnish, and 0.25 part good old honey. Mix carefully, placing the egg-yolk in a shallow vessel, adding the varnish, then thoroughly quirking the two fluids together with a large bristle brush, adding, by means of the brush, foam from a small piece of soap. After thorough mixing, add the vinegar and honey.

A useful Adhesive is made by dissolving 2 parts by weight of the best blued powdered sugar (pulverized white sugar) in 6 to 8 parts by weight of water-glass and about a quarter of a part of glycerine. The sugar dissolves very readily in water-glass, especially if slightly warmed and the glycerine is simply added to the mixture and unites with it. In place of sugar, starch-sugar or syrup may be used, but an adhesive made with this must not be kept for too long a time, because free acids present cause decomposition of the water-glass, whereby the adhesive value is reduced and sometimes completely destroyed.—*Farben-Zeitung.*

Glass Etching Inks.—Diamond ink: Fluoride of ammonia, 1 part, and sulphate of barium, 3 parts, are mixed with sulphuric acid to a thin paste. Durable glass etching ink: Solution 1. Water, 500 parts; fluoride of sodium, 30 parts; sulphate of potassium, 7 parts. Solution 2. Water, 500 parts; chloride of zinc, 14 parts; hydrochloric acid, concentrated, 56 parts. Before use, equal parts of both solutions must be mixed. Separate they do not attack the glass and are of almost unlimited durability. The mixing is best effected in a little leaden saucer. We draw or write with a new steel pen, which, however, is quickly destroyed, or with a goose quill. In place of the lead saucer, we can use a glass or porcelain dish, coated with paraffin. To accomplish this, we pour melted paraffin in the previously warmed dish, distribute it evenly by tilting and turning, pour out the surplus and leave the coating to set.—*Pharm. Post.*

Tobacco Sauces.—Spanish or Seville tobacco (a) 100 parts of finely pulverized Orinoco or Havana tobacco leaf, are treated with a sauce consisting of 4 parts of purified potash, 5 parts pure common salt, 10 parts cinnamon-cassia water, 5 parts meliotus water, 5 parts rose water and 0.14 part of tonka beans, the whole colored with 3 to 4 parts of English red. (b) 100 parts of finely pulverized, large-leaved tobacco, treated with a sauce consisting of 1 part cinnamon-cassia, 0.07 part tonka beans, 6 parts pure common salt, 10 parts cinnamon-cassia water, 5 parts meliotus water and 25 parts of rose-water, colored with 3 to 4 parts of English red. (c) 100 parts of virgin tobacco finely pulverized, treated with a sauce consisting of: 4 parts sweet almonds, 2 parts bitter almonds, 0.28 part saffron, 0.105 part cochineal, 4 parts sal ammonias, 3 parts purified potash, 5 parts pure common salt, 5 parts white sugar, 8 parts Malaga wine, 8 parts cinnamon water, 5 parts rose water, and 0.035 part oil of bergamot. (d) Genuine Seville tobacco (imitation): 100 parts fat Havana leaves. Sauce: 12 parts pure soda, 4 parts tartar salt, 10 parts cinnamon water, 10 parts rose-water, 5 parts melilot clover blossom water, 0.28 part tonka beans, 4 parts sugar syrup, 6 parts good French brandy, 6 parts dark-red sandal wood. In the combined three waters and the wine, the soda and the salt of tartar and syrup are dissolved cold. The tonka beans are rubbed down, with part of the tobacco, to the finest powder and mixed with the tobacco. The mixed flour is then worked in with the fluid, colored and passed through a sieve. After fermentation is completed, this tobacco is ready for use. It is put up in boxes of white tin.

Science Notes

Tantalum Writing Pens.—The excellent properties of tantalum suggested the idea of using this metal for writing pens. Most of the pens now used are of steel, whose elasticity gives the desired pliability to the pens. But the steel pen rusts easily and is attacked by ink. Gold is rustproof and not so attacked. But gold alone is too soft for use in pen nibs, and the extreme points must have some hard metal like iridium soldered to them to make them durable, which is a complicated and expensive task. Tantalum was found to be a perfect substitute, combining the pliable and elastic tenacity of the steel with the chemical stability of the gold. Some very interesting tests have been made by Heintze & Blankert of Berlin. The tantalum metal was cut, formed and split like an ordinary steel pen. Then the points were bent, ground shaped, and hardened by a special hardening process which was found to greatly prolong the life of the pens. Comparative tests were made between steel, gold and tantalum pen points on six miles of paper, and the results showed the hardened tantalum pen to be far superior to the others. The chemical tests showed these pens to be proof against the attack of every ink used, although the pens were exposed to the action of the same for several weeks.—*Vulkan.*

Harmonic Analysis of a Periodic Function.—At a recent meeting of the London Physical Society Prof. Sylvanus P. Thompson described a new and simple method of effecting the analysis into its harmonics of a periodic function. As will be remembered, such a function can always be represented by a Fourier's series of the form:

$$y = A_1 \sin x + B_1 \cos x + A_2 \cos 2x + B_2 \sin 2x + \ldots$$

The problem which has to be solved in analyzing a given curve is to determine the numerical value of the constants A_1, A_2, . . . B_1, B_2, ... The method which Prof. Thompson describes is as follows: In one entire period measure off $2n$ equidistant ordinates, which will therefore be a distance π/n apart. Reversing the sign of every alternate ordinate, their algebraic mean gives the co-efficient required. In the case of the coefficients of the cosines, the first ordinate must be taken at the origin, for the coefficient of the sines it must be taken at the point $\pi/2n$ from the origin. There is one reservation which must be made with regard to this method: If the nth harmonic is being determined, and there are also present the $3n$th, $5n$th, $7n$th, etc., these will be included in the mean obtained, and must be determined separately and eliminated.

Investigation of the Upper Atmosphere.—Mr. Egole, in presenting the report of the committee on the investigation of the upper atmosphere, stated that during the international ascent week, August 7th to 13th, 1911, thirty-one balloons were liberated in the British Isles, nineteen of which were recovered. Successful ascents had also been made on these and other days by Capt. Ley at Oughterard, in Western Ireland, and from Mungret College, Limerick. The curves of height and temperature obtained during these ascents all agreed to their main features. Disregarding certain local irregularities close to the ground, the temperature fell steadily up to a height of about 12 kilometers; then the temperature fall was checked; the temperature either remained stationary or it actually rose again in this isothermal layer; there was hardly any further change in the temperature beyond 14 kilometers up to the maximum heights reached, 17 kilometers and 21 kilometers in two of the Limerick ascents of the past summer. The temperature reversal might amount to 5 deg. or 6 deg. C., and it was assumed that in the highest strata the radiations, upward and downward, finally balanced one another, tending to a definite temperature. The lowest temperatures observed in Ireland, just before entering the isothermal layer, were 212, 213, 216, 217 deg. C. absolute, about 60 deg. C., or 108 deg. F., below freezing point, starting from about 290 deg. C. absolute or 17 deg. C. (62.6 deg. F.) on the ground.—*Engineering.*

TABLE OF CONTENTS

PAGE

Flour Testing.—By F. P. Mann.—1 illustration . . . 337
Radio-Telegraphy. — By Commendatore G. Marconi.—6 illustrations . . . 338
A Unique Temperature Curve Tracer.—3 illustrations . . . 339
Electricity in Ice Plants.—By Aug. C. Smith.—4 illustrations . . . 340
The Parabola in Aeroplane Surfaces.—By G. H. Godley.—3 illustrations . . . 342
Operating Costs of Gas Power Plants . . . 343
German Impulse Marine Turbines.—8 illustrations . . . 344
The Goldschmidt Reaction.—By H. Stanley Redgrove.—2 illustrations . . . 346
Standards of Efficiency . . . 347
Results of Military Aeroplane Tests in France.—8 illustrations . . . 348
Bird Flight.—By Everett H. Bickley.—3 illustrations . . . 349
Large Gas Engines of the Two-cycle Type.—By A. E. L. Chorlton.—13 illustrations . . . 350
Trade Notes . . . 352